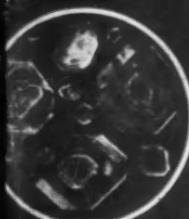


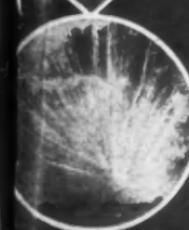
Read Story of Antibiotics

CHEMISTRY

O H I O T U N I V E R S I T Y



APRIL
1946



Nineteenth
Year

ARTICLES YOU CAN UNDERSTAND

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Confusion

► THE TERM ATOMIC ENERGY has entirely different connotations today, depending upon whether the person using it has a scientific outlook or not. This is the root of the major confusion in much of the current discussion of atomic problems. To the scientist, the world stands upon the threshold of the greatest era of scientific discovery imaginable. For him, the war is over, the period in which he can return to constructive research has returned. He finds most of the restrictions imposed for security purposes upon atomic research both useless and infuriating.

The average non-scientist, whether military or civilian, is thinking in terms of atomic bombs. He has an understandable reluctance to being the target for one, and a varying degree of enthusiasm for them as weapons of protection, whether actual or psychological. Add to this divergence the utterances of those vocal minorities purposely adding to the confusion for ulterior political purposes, and you have the current mess.

When the scientist talks about sharing the atomic secret, the technicalities of bomb-making are not what he is talking about. He has never been accustomed to limitation of his thought or of the opportunity to discuss problems with fellow-scientists. Even during war-time a certain amount of information in scientific fields gets through from each side to the other, quietly but quite above-board, for it is essential to the technologic civilization which is necessary to our survival. To ask for limitation of free exchange of information in peace-time is to cripple science in America at the very time when it is most essential to our country's continued progress.

The idealist says, "Wouldn't it be wonderful if there were only some way that the people of the different countries could get together and understand each other? — Alas, it can never be!"

The scientist replies, "We already have such a way. The scientists of the world have been getting together for years, to their mutual advancement and benefit. Why are you trying to destroy this potent force for civilization?"

CHEMISTRY

Vol. 19, No. 8

Formerly The Chemistry Leaflet
Including The Science Leaflet

April 1946

Published monthly by Science Service, Inc., the institution for the popularization of science. Publication Office: 119 South Frazier St., State College, Pa. Entered as second-class matter at the Post Office, State College, Pa., under Act of Congress of March 3, 1879. Address communications to Editorial and Subscription Office: 1719 N St. N.W., Washington 6, D.C.

25c a Copy; \$2.50 a Year. Two-Year Subscription \$4; Your Own and a Gift Subscription \$4. Quantity Subscriptions, 10 or more copies to same address: \$1.70 a Year, \$1 for any seven months, 15c each Copy each Month. No charge for Foreign or Canadian Postage.

Editors: WATSON DAVIS and HELEN MILES DAVIS

Consulting Editor: PAULINE BEERY MACK (Editor 1927-1944.)

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Science Service is the educational and scientific institution organized in 1921 as a non-profit corporation with trustees nominated by the National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, the E. W. Scripps Estate and the Journalistic Profession.



► Dr. WAKSMAN, discoverer of streptomycin, at the Fifth Science Talent Institute with some of the boys and girls to whom he told the following story of the antibiotics, newest of biological chemicals.

The Story of Antibiotics

by SELMAN A. WAKSMAN

Professor of Microbiology, Rutgers University and Microbiologist, New Jersey Agricultural Experiment Station

► My story of antibiotics can well be begun with a story of the microbes, those tiny, microscopic forms of life that are found everywhere around us, namely, in the soil and in the sea, as well as in other water basins, in our clothing, in the air that we breathe, and on as well as in our own

bodies. These lowly living systems, or as they are usually called, microbes are divided into several groups on the basis of their size, structure, and mode of nutrition into the bacteria, molds or fungi, algae, and microscopic animal forms such as protozoa and worms. They can also be

divided on the basis of their relation to man, into saprophytic and parasitic or pathogenic forms, or into useful and harmful organisms. It is practically synonymous to designate them as our friends or our enemies.

Friendly Microbes

The useful or the friendly microbes are largely found in the soil and in the sea, in river and in lake waters and in sewage disposal systems. They destroy the residues of plant and animal life, and liberate back into circulation the essential chemical elements necessary for plant growth. They also participate in a number of other processes highly essential for plant and animal life, as in the fixation of atmospheric nitrogen, whereby the inert nitrogen gas of the atmosphere above us is transformed into a combined form, when it can be utilized for fresh plant life. Since animals depend upon plants for their sustenance, it is transformed also into animal forms of life. Man has succeeded in domestication of many of the useful microbes to serve him in his needs and in his struggle to survive. He utilizes the activities of these microbes in the preparation of his foodstuffs, as in the baking of bread, ripening of cheese, flavoring of butter and production of certain vitamins; in the fermentation of his beverages, as in the making of wine, beer and distilled liquors; in the production of a variety of industrially important chemical compounds, such as alcohols (ethyl, butyl), organic acids (acetic, lactic, citric, gluconic), acetone, glycerol; as well as in various other processes that

serve to make man's life on this planet more secure, more rich and more pleasant.

Enemy Microbes

The harmful or injurious microbes, on the other hand, include those that destroy our crops, spoil our foodstuffs, attack our textiles and our habitations, and cause a great variety of other forms of damage to man's economy; also those that attack our own bodies and the bodies of our domesticated and wild animals. These pathogenic microbes cause a variety of diseases and are responsible for the numerous infections and epidemics that have befallen mankind since times immemorial. Some of these diseases are acute, such as pneumonia, typhoid, dysentery, diphtheria, cholera, plague, typhus and the numerous colds, whereas other diseases are chronic in nature, such as undulant fever and tuberculosis; there are many gradations between. These infectious diseases are caused by bacteria, fungi, protozoa, viruses, and various other microbes.

One may now inquire into the possible interrelations between microbes, and especially the effects of the saprophytic forms upon one pathogen. This question has aroused the curiosity of the scientific investigator since the early days of microbiology. As soon as it became recognized that most of the human and animal infections are caused by bacteria and other microbes that infect the body, multiply there and bring about the disease, the bacteriologist began to inquire, what becomes of the many millions of microbes that each sufferer secretes daily. This

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► AT THE NATIONAL ACADEMY of Sciences meeting in April 1940, Dr. Waksman showed this plate, with its two crosses of germ growth. The complete cross is formed by a culture of organisms from the soil, streaked across the agar surface. The second cross, streaked from a culture of a different organism, has been partly obliterated by anti-biotic action of some principle given off by the earth organisms. His persistent search for this principle has been rewarded by production of streptomycin.

was not merely idle curiosity. The physician and the sanitarian and public health officers have learned what a heavy price society has to pay when such excreted microbes are not disposed of properly. This was known to have been the cause of the numerous epidemics that ravaged mankind since the dawn of history. Some of these epidemics, namely bubonic

plague and cholera, scarlet fever and diphtheria, typhus and influenza have often resulted in the decimation of a large portion of the population, ranging from that of a small community to that of a whole continent. It was known, for example, that a single typhoid carrier can bring an epidemic of typhoid to a whole community, by infecting its milk supply,

or its bread or confectionary supply. Many an epidemic has been traced to improper sewage disposal or to an unsanitary water condition. Since all human and animal excreta find their way, sooner or later, into the soil, it was no wonder that the early bacteriologists looked into the soil and asked a very pertinent question: What becomes of all the pathogenic bacteria?

The soil was carefully examined bacteriologically and, after detailed studies, the conclusion was reached that, with very few exceptions, bacteria responsible for the numerous infections and epidemics do not survive long there. If a typhoid patient was allowed to urinate on fresh soil, the bacteria were dead even before the excess moisture had evaporated. Similar observations were made for the survival and destruction of the diphtheria organism, the cholera bacteria, and a number of others. It was reported, for example, that the organism causing malta fever, a close relative to that which is responsible for undulant fever in man and for infectious abortion in cattle, survived 69 days in dry sterile soil and 80 days on dry cloth but only 20 days in unsterile manured soil.

These findings were important in establishing the fact that the soil need not be feared as a possible source of epidemics or infections, with only very few exceptions, such as tetanus, anthrax, and gas gangrene. But even more important, however, was the gradual recognition of the fact that pathogenic microbes disappear in the soil not because they are unable to survive there but largely due to the presence of certain agents that are

responsible for their destruction. This was substantiated by the following two observations: (1) when a soil is sterilized, many of the disease-producing bacteria are not only able to survive there but many actually multiply. (2) Repeated additions of certain bacteria to a given soil may result in their accelerated destruction. Other observations as well led to the conclusion that the presence of saprophytic microbes in a mixed microbiological population modify considerably the activities of the disease-producing organisms or may even be responsible for their destruction.

Saprophytic Microbes

The above facts could lead to only one conclusion, namely, that certain of the friendly soil microbes are responsible for the destruction of the disease-producing forms brought into the soil. Once this fact became established, the question was logically raised whether some of the friendly or saprophytic microbes can actually be utilized for the purpose of combating human infections. An answer to that question was given in a prophetic vein by Louis Pasteur, the leading pioneer in microbiology and the greatest bacteriologist that ever lived. When he observed that a culture of the anthrax bacillus that he used to inoculate sheep did not develop the disease when it became contaminated with another organism, he stated that the ability of certain "common bacteria" to prevent the development of an important disease such as anthrax may lead to great developments in therapeutics.

Unfortunately, the progress made in the utilization of saprophytic microbes for the purpose of controlling

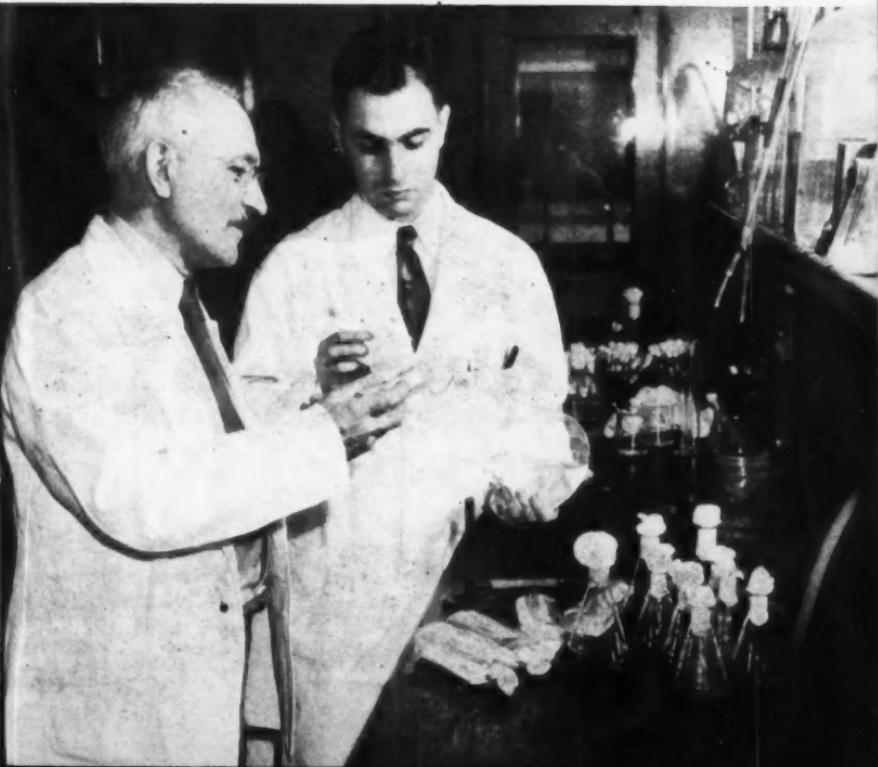
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diseases and infections caused by pathogenic ones was at first very slow. This was due primarily to the fact that the manner of destruction of the pathogen by the saprophyte was only little understood. Living microbes could not be used for injecting into the animal body, since they would not develop there or might even cause undesirable symptoms. The application of the newly discovered principle of therapy had to wait, therefore, until the active principles or the chemical agent, produced by the saprophytes and capable of destroying the pathogens, could be isolated from the culture of the antagonistic microbe. These principles or agents have been recently designated as antibiotics, because of their specific effects upon living systems. Suitable organisms had to be selected, proper conditions for their cultivation and large scale growth had to be developed, and chemical methods found for the isolation of the active agents. Not until then could the new science of antibiotics take its place among the other sciences, bordering on the fields of microbiology and chemistry, with applications in medicine and to veterinary science.

► IN HIS LABORATORY in New Brunswick, N. J., Dr. Selman A. Waksman and his assistant, Dr. Albert Schatz, experiment with penicillin-resistant disease germs, many of which are killed by streptomycin.



Antibiotics

What is an antibiotic? An antibiotic is a chemical substance produced by microorganisms and by certain higher forms of life, which has the property of inhibiting the growth of and even of killing bacteria and other microbes. Antibiotics are characterized by certain properties which distinguish them from the common antiseptics and disinfectants. These properties can be briefly summarized as follows:

Antibiotics are selective in their action upon bacteria, some bacteria being sensitive and others resistant. Each antibiotic is characterized by a specific bacteriostatic or antibacterial spectrum, namely its selective action upon a variety of different bacteria.

Antibiotics differ greatly in their chemical nature. Some are nitrogen free, others contain nitrogen, and still others contain both nitrogen and sulfur. Some are lipoïd-like materials, others are characterized by their ring structure; some are polypeptides, and some are basic compounds containing a carbohydrate group.

Antibiotics differ greatly in their toxicity to animals. Some are non-toxic, some are highly toxic and most fall between these two extremes. They also vary in their effect upon animal tissues and body fluids, some being hemolytic and others not.

Antibiotics vary greatly not only in their *in vitro*, but also in their *in vivo* activities. Some are equally effective *in vitro* and *in vivo*. Others are not active at all in the animal body, or their activity is greatly reduced by the body constituents.

Because of their selective activities,

some antibiotics injected into the body tissues exert a marked effect upon the bacteria, without affecting the tissues themselves.

Antibiotics vary in their mode of action upon bacteria, the difference being frequently more a matter of degree than of kind. They interfere with certain mechanisms involved in the nutrition and multiplication or growth of the bacterial cell. It is of special importance to note the fact that different strains of the same organism may vary greatly in the sensitivity to a given antibiotic. Various bacteria have the capacity of adjusting themselves to withstand increasing concentrations of the antibiotic. This phenomenon is of great importance in chemotherapy where the same material may have to be used for a prolonged period of time.

Antibiotics vary greatly in their physical and chemical properties, namely solubility, some being soluble in water and others only in organic solvents, such as alcohol, ether and acetone.

Antibiotics vary in their therapeutic potentialities. Some are highly effective in parenteral or internal administration, whereas others can be used only topically or for surface application. It can readily be recognized from these characterizations that only very few antibiotics have so far found practical application in disease control.

Antibiotics are produced by a large number of fungi, actinomycetes and bacteria. Microorganisms capable of producing antibiotics are frequently spoken of as antagonistic forms. Various methods have been developed for

the isolation from natural substrates, such as soils, manures and even dust, of antagonistic microorganisms in pure culture and for testing their antibacterial potency. Frequently the soil enrichment method is used previous to the isolation of the organisms. This method is based upon the fact that repeated additions of living suspensions of bacteria to a soil may favor the development of microbes capable of destroying such bacteria. More recently, it has been shown that this procedure is of questionable value in the isolation of suitable antagonistic microorganisms.

Antagonistic Properties

The simplest method of testing organisms for their antagonistic or antimicrobial properties consists in streaking the culture of the organism on a suitable agar medium in a Petri plate, allowing it to incubate for 24 to 48 hours, then streaking towards it several test bacteria or fungi. The width of the zone of inhibition of the various test organisms will not only be a measure of the ability of a given culture to produce antibiotics, but will also serve as a measure of the selective antimicrobial action of such antibiotics.

Once a culture of an antagonist has been selected either because of its potency or because of its selective antibacterial activity, suitable media and proper methods of culture are developed for its growth and the production of the given antibiotic. The maximum activity is usually produced in 2 to 5 days in deep or submerged culture in tanks, and in 7 to 14 days in stationary culture in flasks or bottles. The antibiotic is

usually found in the liquid medium from which it is isolated by means of suitable chemical procedures. Some of the common methods consist in adsorbing the active substance on charcoal, then removing the adsorbing agent by an acid or an alkaline solution or by means of an organic solvent. The antibiotic may also be directly extracted from the medium by certain organic solvents, such as ether, acetone, or chloroform. Further concentration and purification is carried out by suitable chemical procedures.

The antibiotic thus isolated is first tested for its antibacterial properties *in vitro*, in order to determine whether one is still dealing with the same type of substance that was originally present in the culture, since frequently some organisms produce more than one antibiotic. Next, experimental animals are used for determining its toxicity and *in vivo* activity. After such exhaustive tests have been made one can attempt to try the newly isolated agent in the treatment of human infections.

Although some 100 different antibiotics have now been isolated, only very few have found practical application. Among these, three occupy a prominent place, namely, tyrothrinacin, penicillin, and streptomycin. Although several others have been considered at one time or another, they either proved to be unsuitable on further study, as in the case of clavacin, or they have not been as yet sufficiently tested, as in the case of subtilin. The further discussion may be limited to the above three antibiotics.

Tyrothricin

Tyrothricin was first discovered in this country by Dr. Dubos of the Rockefeller Institute in 1939. It is produced by certain spore-forming aerobic soil bacteria of the *Bacillus brevis* type. The substance is a polypeptide or rather a group of polypeptides, some of which have been crystallized and designated by different names, such as gramicidin and tyrocidine. *Tyrothricin* is active largely against the bacteria of the gram-positive type. However, since it brings about hemolysis of the red blood cells, its chemotherapeutic use is limited to surface treatments. It has found application in a variety of human and animal infections, such as sinus conditions and mastitis in cattle.

Penicillin

Penicillin, probably the most non-toxic drug now known, is produced by various green molds belonging to the *Penicillium notatum*—*P. chrysogenum* group. These molds occur abundantly in the soil and in the dust. Different cultures vary greatly in their capacity to produce penicillin. A selected culture of the molds is allowed to grow in a suitable medium and the penicillin thus produced is either first adsorbed on charcoal, followed by removal with organic solvents, or extracted directly from the medium, using suitable solvents. Penicillin has been crystallized and found to contain both nitrogen and sulfur in its molecule. At least 5 different types of penicillin have now been isolated; they differ both in their chemical structure and in their antibacterial properties. Penicillin is active largely against gram-positive

bacteria and also certain gram-negative forms. Due to its lack of toxicity, it can be injected directly into the blood stream. It has been used effectively in the treatment of numerous diseases. These comprise various staphylococci and streptococci infections, such as carbuncles, endocarditis, wound or burn infections, osteomyelitis, all gas gangrene, malignant edema, mastoiditis, pneumococcal infections, gonococcal and meningococcal infections, anthrax and many others. Penicillin is not active against most of the gram-negative bacteria, such as typhoid, paratyphoid, pertussis, tularemia, and others; it is also inactive against tuberculosis and a variety of other diseases.

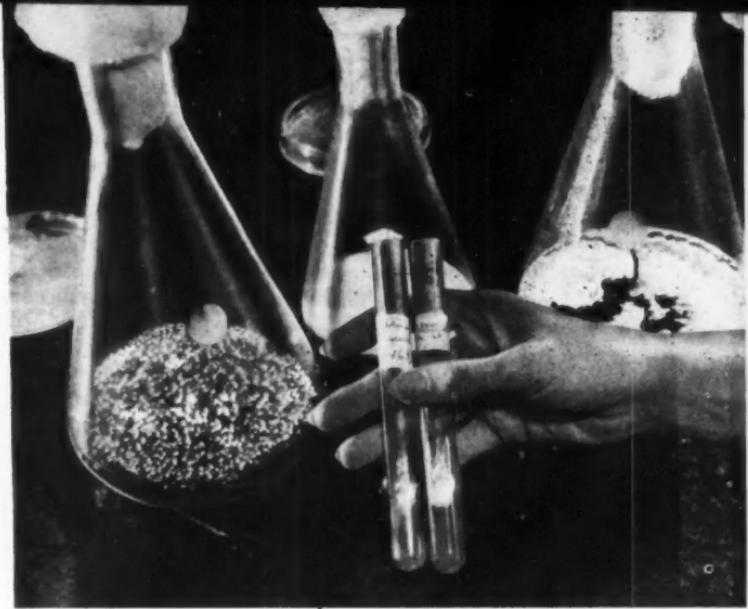
Streptomycin

Streptomycin is produced by *Streptomyces griseus*, belonging to the actinomycetes, a group of organisms considered by bacteriologists to be higher bacteria and by mycologists to be lower fungi. Only very few strains of this organism were found capable of producing streptomycin. The organism is grown in suitable organic media containing certain essential "precursors" as found in meat extract or corn steep. The culture is then filtered or centrifuged, and the filtrate treated with charcoal, which adsorbs the streptomycin. The latter is removed with acid alcohol. Streptomycin has now been crystallized and is found to consist of a basic compound, containing a guanidine and a nitrogenous sugar group. Streptomycin is soluble in water, but not in organic solvents. It is not very toxic to animals. It has been used successfully in the treatment of a variety of diseases, such

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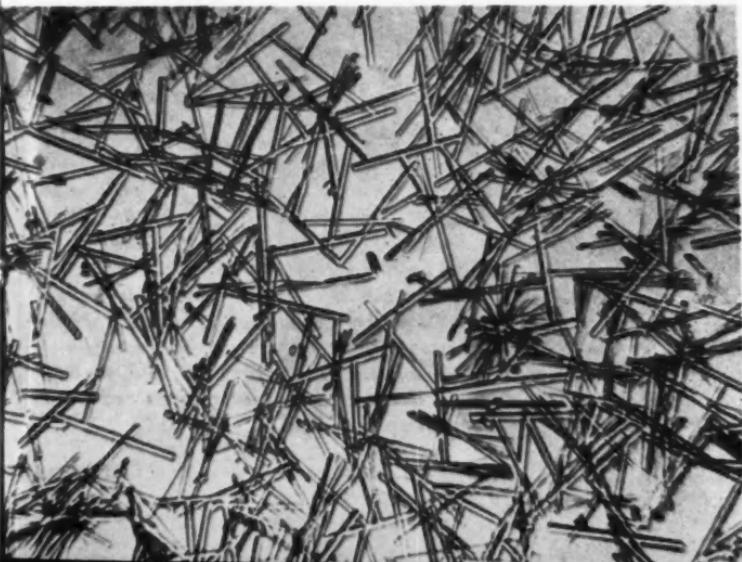
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—Photo by Fremont Davis, Science Service

► *STREPTOMYCES GRISEUS* grows in the flask on the right as a cottony mat. In the flask on the left, shaken while the organisms were growing, they look like haulstones. Streptomycin, the anti-biotic obtained from this organism, has been isolated in crystalline form as the trihydrochloride-calcium chloride double salt. These crystals are shown in the lower picture.

—Photo by Merck & Co.



as urinary infections, tularemia, influenza, meningitis, whooping cough; it appears to have a decided effect upon certain forms of tuberculosis and other important diseases.

The subject under consideration, namely, the new branch of science known as that of antibiotics, offers many broad horizons for investigators in various fields:

1. To the microbiologist, it offers an opportunity for searching for new organisms that produce other antibiotics or better forms of those already known; it also offers an excellent tool for the study of the life and death of the bacterial cell.

2. To the chemist, it offers not only new types of important compounds, the structure and composition of which remain to be unravelled, but it also opens a broad field for synthesis of new and more effective chemical agents that can be utilized for therapeutic purposes.

3. To the physiologist, the pathologist, and the pharmacologist it offers new tools for the study of the nature of infection, the interaction between

All of the foregoing photographs except Service staff photographer.

the infecting agent and the body tissues.

4. Finally, and most important, to the medical profession it offers a new group of tools for combating infections and epidemics. Whereas only 10 or so years ago, it was believed doubtful whether a drug could ever be found for the treatment of generalized infections caused by bacteria, the sulfa drugs which are products of the laboratory, and the antibiotics which are produced by microbes are rapidly filling this great need. One may look forward to the time when a physician will have at his disposal a large number of drugs, each most effective in the treatment of a particular disease condition. Although many infections, notably those caused by viruses, still remain uncontrollable, the hope exists that, sooner or later, these as well may come under control.

It is to you, the scientists of the future, that we are all looking to enlarge our knowledge, to discover new scientific principles, and to apply those already known to improving the health and the very life of man.

as noted, are by Fremont Davis, Science

Fifth Science Talent Search Essays

► BEGINNING ON page 47 are essays of some of the Fifth Science Talent Search trip winners who carried out their projects in the field of chemistry. Pictures taken at the Science Talent Institute show some of the boys and girls at the sessions and with the exhibits of their work that they arranged for Hobby Night. Although the essays are not the deciding factor in selection of the winners, the judges of the Science Talent Search feel that they afford interesting evidence of the students' originality in choice of project and method of attack. Top honors in the Fifth S.T.S. went to biologists, but the chemists had interesting projects, and CHEMISTRY offers these essays as examples of the sort of research programs high school seniors can carry out, and, perhaps, as inspiration for next year's seniors. Get started on your projects early, boys and girls of the Sixth Science Talent Search, 1946-7!

I Got Previous Experience With This 'Stuff'



—Cartoon by Herblock, courtesy The Washington Post.

First of Three Parts:
State Department Report

International Atomic Control

This is the actual text of the historic State Department document titled: "A Report on the International Control of Atomic Energy." It was prepared for the Secretary of State's Committee on Atomic Energy by a board of consultants, of which the chairman was David E. Lilienthal. The report itself is dated March 16, 1946 and it was made public on March 29. The opposite page is set to give the typographical flavor of the report itself, for the mode of presentation and the committee within committee aspect is as much a part of the report as the content and the recommendations which begin textually on page 16. Reprinting of the report will be completed in the May and June issues of CHEMISTRY.

Forward by the Secretary of State

► THIS "Report on the International Control of Atomic Energy" is in the main the work of a Board of Consultants to the Department of State. The Board carried out its assignment under the general direction of a Committee on Atomic Energy which I set up on January 7, 1946 with Dean Acheson, Under Secretary of State, as Chairman. A letter of transmittal at the beginning of the Report embodies the comments which Mr. Acheson's Committee made on the unanimous findings and recommendations of the Board of Consultants.

In thus transmitting to me the detailed report of the Board, the Committee emphasizes the Board's observation that the Report is not intended

as a final plan but "a place to begin, a foundation on which to build." The Committee also states that it regards the consultants' work as "the most constructive analysis of the question of international control we have seen and a definitely hopeful approach to a solution of the entire problem."

The intensive work which this document reflects and the high qualifications of the men who were concerned with it make it a paper of unusual importance and a suitable starting point for the informed public discussion which is one of the essential factors in developing sound policy. The document is being made public not as a statement of policy but solely as a basis for such discussion.

**THE UNDER SECRETARY OF STATE
WASHINGTON**

The Honorable
James F. Byrnes,
Secretary of State,
Washington, D. C.

March 17, 1946

Dear Mr. Secretary:

Your committee was appointed on January 7, 1946, with the following terms of reference:

"Anticipating favorable action by the United Nations Organization on the proposal for the establishment of a commission to consider the problems arising as to the control of atomic energy and other weapons of possible mass destruction, the Secretary of State has appointed a Committee of five members to study the subject of controls and safeguards necessary to protect this Government so that the persons hereafter selected to represent the United States on the Commission can have the benefit of the study."

At our first meeting on January 14, the Committee concluded that the consideration of controls and safeguards would be inseparable from a plan of which they were a part and that the Commission would look to the American representative to put forward a plan. At that meeting we also agreed that it was first essential to have a report prepared analyzing and appraising all the relevant facts and formulating proposals. In order that the work should be useful, it was necessary to designate men of recognized attainments and varied background, who would be prepared to devote the major part of their time to the matter.

On January 23, 1946, we appointed as a Board of Consultants for this purpose:

MR. DAVID E. LILIENTHAL, Chairman of the Tennessee Valley Authority, who acted as Chairman of the consulting Board,

MR. CHESTER I. BARNARD, President of the New Jersey Bell Telephone Company,

DR. J. ROBERT OPPENHEIMER, of the California Institute of Technology and the University of California.

DR. CHARLES ALLEN THOMAS, Vice

President and Technical Director, Monsanto Chemical Company, and

MR. HARRY A. WINNE, Vice-President in Charge of Engineering Policy, General Electric Company.

The Board of Consultants has spent virtually its entire time, since the date of appointment, in an intensive study of the problem, and has now completed its report, which is transmitted herewith.

A preliminary draft of this report was first presented to your Committee ten days ago. Extensive discussion between the Committee and the Board led to the development of further considerations embodied in a subsequent draft. Still further discussion resulted in the report now transmitted.

We lay the report before you as the Board has submitted it to us "not as a final plan, but as a place to begin, a foundation on which to build." In our opinion it furnishes the most constructive analysis of the question of international control we have seen and a definitely hopeful approach to a solution of the entire problem. We recommend it for your consideration as representing the framework within which the best prospects for both security and development of atomic energy for peaceful purposes may be found.

In particular, we are impressed by the great advantages of an international agency with affirmative powers and functions coupled with powers of inspection and supervision in contrast to any agency with merely police-like powers attempting to cope with national agencies otherwise restrained only by a commitment to "outlaw" the use of atomic energy for war. In our judgment the latter type of organization offers little hope of achieving the security and safeguards we are seeking.

We are impressed also by the aspect of the plan which concentrates in the hands of the international agency only the activities which it is essential to control because they are dangerous to international security, leav-

ing as much freedom as possible to national and private research and other activity.

We wish to stress two matters brought out in the Board's report—matters of importance in considering the report's proposals as they affect the security of the United States both during the period of any international discussion of them and during the period required to put the plan into full effect.

The first matter concerns the disclosure of information not now generally known. The report points out that the plan necessitates the disclosure of information but permits of the disclosure of such information by progressive stages. In our opinion various stages may upon further study be suggested. It is enough to point out now that there could be at least four general points in this progression. Certain information, generally described as that required for an understanding of the workability of proposals, would have to be made available at the time of the discussions of the proposals in the United Nations Atomic Energy Commission, of the report of the Commission in the Security Council and General Assembly of the United Nations and in the national legislatures which would be called upon to act upon any recommendations of the United Nations. We have carefully considered the content of this information, and in our discussions with the Board have defined it within satisfactory limits. We estimate the degree of its importance and the effect of its disclosure to be as follows: If made known to a nation otherwise equipped

by industrial development, scientific resources and possessing the necessary raw materials to develop atomic armament within five years, such disclosure might shorten that period by as much as a year. Whether any nation—we are excluding Great Britain and Canada—could achieve such an intensive program is a matter of serious doubt. If the program were spread over a considerably longer period, the disclosure referred to would not shorten the effort appreciably.

The next stage of disclosure might occur when the proposed international organization was actually established by the action of the various governments upon the report of the United Nations. At this time the organization would require most of the remaining scientific knowledge but would not require the so-called technical know-how or the knowledge of the construction of the bomb.

By the time the organization was ready to assume its functions in the field of industrial production it would, of course, require the technological information and know-how necessary to carry out its task. The information regarding the construction of the bomb would not be essential to the plan until the last stage when the organization was prepared to assume responsibility for research in the field of explosives as an adjunct to its regulatory and operational duties.

The second matter relates to the assumption or transfer of authority over physical things. Here also the plan permits of progress by stages beginning in the field of raw material production, progressing to that of in-

dustrial production, and going on to the control of explosives.

The development of detailed proposals for such scheduling will require further study and much technical competence and staff. It will be guided, of course, by basic decisions of high policy. One of these decisions will be for what period of time the United States will continue the manufacture of bombs. The plan does not require that the United States shall discontinue such manufacture either upon the proposal of the plan or upon the inauguration of the international agency. At some stage in the development of the plan this is required. But neither the plan nor our transmittal of it should be construed as meaning that this should or should not be done at the outset or at any specific time. That decision, whenever made, will involve considerations of the highest policy affecting our security, and must be made by our government under its constitutional processes and in the light of all the facts of the world situation.

Your Committee, Mr. Secretary, awaits your further instructions as to whether you believe it has performed the task you assigned to it and may now be discharged or whether you wish it to go further in this field under your guidance.

Respectfully submitted,
DEAN ACHESON
Chairman
VANNEVAR BUSH
JAMES B. CONANT
LESLIE R. GROVES,
Major General, USA
JOHN J. McCLOY

Foreword

► THE BOARD of consultants met for the first time on January 23rd, conferring briefly with the Secretary of State's Committee on Atomic Energy respecting the board's assignment to study the problem of international control of atomic energy. For more than seven weeks since that time we devoted virtually our entire time and energies to the problem we were directed to study and report upon. We visited the plants and installations at Oak Ridge, Tennessee, and Los Alamos, New Mexico, and spent days consulting with numerous scientists, industrial experts, and geologists, authorities in the technical fields concerned with atomic energy. Since February 25th this board has met almost continuously, developing and writing the following report. Our absorption in this task does not, of course, assure the soundness of the recommendation which is the product of our deliberations. But it is relevant as a measure of how important and urgent we feel it to be that the Government and the people of the United States develop a rational and workable plan, before the already launched international atomic armament race attains such momentum that it cannot be stopped.

We have concluded our deliberations on this most difficult problem, not in a spirit of hopelessness and despair, but with a measure of confidence. It is our conviction that a satisfactory plan can be developed, and that what we here recommend can form the foundation of such a plan. It is worth contrasting the sense of hope and confidence which

all of us share today with the feeling which we had at the outset. The vast difficulties of the problem were oppressive, and we early concluded that the most we could do would be to suggest various alternative proposals, indicate their strengths and limitations, but make no recommendations. But as we steeped ourselves in the facts and caught a feel of the nature of the problem, we became more hopeful. That hopefulness grew not out of any preconceived "solution" but out of a patient and time-consuming analysis and understanding of the facts that throw light on the numerous alternatives that we explored. Five men of widely differing backgrounds and experiences who were far apart at the outset found themselves, at the end of a month's absorption in this problem not only in complete agreement that a plan could be devised but also in agreement on the essentials of a plan. We believe others may have a similar experience if a similar process is followed.

We have described the process whereby we arrived at our recommendation, to make it clear that we did not begin with a preconceived plan. There is this further reason for describing this process. Others would have a similar experience if they were able to go through a period of close study of the alternatives and an absorption in the salient and determining facts. Only then, perhaps, may it be possible to weigh the wisdom of the judgment we have reached, and the possibilities of building upon it.

The Commitment

► WE WERE GIVEN as our starting point a political commitment already made by the United States to seek by all reasonable means to bring about international arrangements to prevent the use of atomic energy for destructive purposes and to promote the use of it for the benefit of society. It has not been part of our assignment to make a detailed analysis of the arguments which have led the Government of the United States in concert with other nations to initiate these steps for international action. By way of background, however, it is useful to review some of the main reasons which have influenced the people of the United States and its Government in this course. These reasons were first definitely formulated in the Agreed Declaration of November 15, 1945, issued by the President of the United States and the Prime Ministers of the United Kingdom and Canada. An understanding of the declarations in that document will itself throw considerable light on the criteria by which any specific proposals for international control may be judged.

The Agreed Declaration cites three reasons for seeking international control. This Declaration recognizes that the development of atomic energy, and the application of it in weapons of war, have placed at the disposal of mankind "means of destruction hitherto unknown." The American people have been quick to recognize the really revolutionary character of these weapons, particularly as weapons of strategic bombardment aimed at the destruction of

enemy cities and the eradication of their populations. Enough has been said to make unnecessary a repetition of the probable horrors of a war in which atomic weapons were used by both combatants against the cities of their enemy. But it is hardly possible to overestimate the deep impression of horror and concern which insight into these future possibilities has made so widespread.

The second point recognized in the Agreed Declaration is that there can be no adequate military defense against atomic weapons. A great mass of expert testimony is involved in an appreciation of the firmness of this point, but it appears to be accepted without essential reservation, and subject only to an appropriate openmindedness, about what the remote future of technical developments in the arts of war may bring.

The third part, and again we quote from the Agreed Declaration, is that these are weapons "in the employment of which no single nation can in fact have a monopoly." Of the three, this is perhaps the most controversial. Strong arguments have been brought forward that the mass of technical and scientific knowledge and experience needed for the successful development of atomic weapons is so great that the results attained in the United States cannot be paralleled by independent work in other nations. Strong arguments have also been put forward that the degree of technical and industrial advancement required for the actual realization of atomic weapons could hardly be found in other parts of the world. These arguments have been met with great and widespread

skepticism. It is recognized that the basic science on which the release of atomic energy rests is essentially a world-wide science, and that in fact the principal findings required for the success of this project are well known to competent scientists throughout the world. It is recognized that the industry required and the technology developed for the realization of atomic weapons are the same industry and the same technology which play so essential a part in man's almost universal striving to improve his standard of living and his control of nature. It is further recognized that atomic energy plays so vital a part in contributing to the military power, to the possible economic welfare, and no doubt to the security of a nation, that the incentive to other nations to press their own developments is overwhelming.

Thus the Agreed Declaration bases its policy on the revolutionary increase in the powers of destruction which atomic weapons have injected into warfare, and on the fact that neither countermeasures nor the maintenance of secrecy about our own developments offers any adequate prospect of defense.

There are perhaps other considerations which have contributed to the popular understanding of the necessity for international control, although they do not appear explicitly in the Agreed Declaration. The United States is in a rather special position in any future atomic warfare. Our political institutions, and the historically established reluctance of the United States to take the initiative in aggressive warfare, both would seem

to put us at a disadvantage with regard to surprise use of atomic weapons. This suggests that although our present position, in which we have a monopoly of these weapons, may appear strong, this advantage will disappear and the situation may be reversed in a world in which atomic armament is general.

The atomic bomb appeared at the very end of hostilities at a time when men's thoughts were naturally turning to devising methods for the prevention of war. The atomic bomb made it clear that the plans which had been laid at San Francisco for the United Nations Organization would have to be supplemented by a specific control of an instrument of war so terrible that its uncontrolled development would not only intensify the ferocity of warfare, but might directly contribute to the outbreak of war. It is clear, too, that in the solution of this relatively concrete and most urgent problem of protecting mankind from the evils of atomic warfare, there has been created an opportunity for a collaborative approach to a problem which could not otherwise be solved, and the successful international solution of which would contribute immeasurably to the prevention of war and to the strengthening of the United Nations Organization. On the one hand, it seemed unlikely that the United Nations Organization could fulfill its functions without attempting to solve this problem. On the other hand, there was hope and some reason to believe that in attempting to solve it, new patterns of cooperative effort could be established which would be capable of extension to other fields,

and which might make a contribution toward the gradual achievement of a greater degree of community among the peoples of the world. Although these more general considerations may appear secondary to the main purposes of this report, they are not irrelevant to it. There is another phrase of the Agreed Declaration which rightly asserts "that the only complete protection for the civilized world from the destructive use of scientific knowledge lies in the prevention of war."

The proposals which we shall make in this report with regard to the international control of atomic energy must of course be evaluated against the background of these considerations which have led to the universal recognition of the need for international control. We must ask ourselves to what extent they would afford security against atomic warfare; to what extent they tend to remove the possibility of atomic weapons as a cause of war; to what extent they establish patterns of cooperation which may form a useful precedent for wider application. We ourselves are satisfied that the proposals in this report provide the basis of a satisfactory answer to these questions.

Early Ideas on Safeguards

So much for the main outline of the political action that led to the setting up of the United Nations Commission on atomic energy. There is a further aspect of the general background that also requires discussion at the outset. When the news of the atomic bomb first came to the world there was an immediate reaction that a weapon of such devastat-

ing force must somehow be eliminated from warfare; or to use the common expression, that it must be "outlawed." That efforts to give specific content to a system of security have generally proceeded from this initial assumption is natural enough. But the reasoning runs immediately into this fact: The development of atomic energy for peaceful purposes and the development of atomic energy for bombs are in much of their course interchangeable and inter dependent. From this it follows that although nations may agree not to use in bombs the atomic energy developed within their borders, the only assurance that a conversion to destructive purposes would not be made would be the pledged word and the good faith of the nation itself. That this fact puts an enormous pressure upon national good faith and that indeed it creates suspicion on the part of other nations that their neighbors' pledged word will not be kept is accentuated by the unusual characteristics of atomic bombs, namely their devastating effect as a surprise weapon, that is, a weapon secretly developed and used without warning. Fear of such surprise violation of pledged word will surely break down any confidence in the pledged word of rival countries developing atomic energy if the treaty obligations and good faith of the nations are the only assurances upon which to rely.

Such considerations have led to a preoccupation with systems of inspection by an international agency to forestall and detect violations and evasions of international agreements not to use atomic weapons. For it

was apparent that without international enforcement no system of security holds any real hope at all.

In our own inquiry into possibilities of a plan for security we began at this point, and studied in some detail the factors which would be involved in an international inspection system supposed to determine whether the activities of individual nations constituted evasions or violations of international outlawry of atomic weapons.

We have concluded unanimously that there is no prospect of security against atomic warfare in a system of international agreements to outlaw such weapons controlled *only* by a system which relies on inspection and similar police-like methods. The reasons supporting this conclusion are not merely technical, but primarily the inseparable political, social, and organizational problems involved in enforcing agreements between nations each free to develop atomic energy but only pledged not to use it for bombs. National rivalries in the development of atomic energy readily convertible to destructive purposes are the heart of the difficulty. So long as intrinsically dangerous activities may be carried on by nations, rivalries are inevitable and fears are engendered that place so great a pressure upon a system of international enforcement by police methods that no degree of ingenuity or technical competence could possibly hope to cope with them. We emphasize this fact of national rivalry in respect to intrinsically dangerous aspects of atomic energy because it was this fatal defect in the commonly advanced proposals for outlawry of

atomic weapons coupled with a system of inspection that furnished an important clue to us in the development of the plan that we recommend later in this report.

We are convinced that if the production of fissionable materials by national governments (or by private organizations under their control) is permitted, systems of inspection cannot by themselves be made "effective safeguards . . . to protect complying states against the hazards of violations and evasions."

It should be emphasized at this point that we do not underestimate the need for inspection as a component, and a vital one, in any system of safeguards—in any system of effective international controls. In reading the remainder of this section it is essential to bear in mind that throughout the succeeding sections of this report we have been concerned with discovering what other measures are required in order that inspection might be so limited and so simplified that it would be practical and could aid in accomplishing the purposes of security.

The remainder of this section, however, is concerned with outlining the reasons for our conclusion that a system of inspection superimposed on *an otherwise uncontrolled exploitation of atomic energy by national governments* will not be an adequate safeguard.

Problem of Inspection

Although, as we have said, a system of inspection cannot be judged on technical grounds alone, an understanding of the technical problem is necessary in order to see what an in-

spection system would involve. The general purpose of such inspection (that is, inspection as the sole safeguard) would be to assure observance of international agreements according to which certain national activities leading more or less definitely to atomic armament would be renounced, and others which have as their purpose peaceful applications of atomic energy would be permitted. The fact that in much of their course these two types of activity are identical, or nearly identical, makes the problem one of peculiar difficulty.

In our study of the technical factors involved in appraising systems of inspection, we were greatly aided by consultations with the Technical Committee reporting to the War Department on the technical aspects of this problem.* We are indebted to this uniquely qualified group of experts for helpful discussions and for making available to us many of their reports, without which we should doubtless have been very much slower to understand the situation.

As a result of our work with this Committee, we are clear: that every stage in the activity, leading from raw materials to weapon, needs some sort of control, and that this must be exercised on all of the various paths that may lead from one to the other; that at no single point can *external* control of an operation be sufficiently reliable to be an adequate sole safeguard; that there is need for a very extensive and technically highly qualified and varied staff if the job is to

be done at all; that the controlling agency must itself be active in research and development, and well informed on what is an essentially living art; and that, for effective control, the controlling organization must be as well and as thoroughly informed about the operations as are the operators themselves. Finally—and this we regard as the decisive consideration—we believe that an examination of these and other necessary preconditions for a successful scheme of inspection will reveal that *they cannot be fulfilled in any organizational arrangements in which the only instrument of control is inspection.*

A fundamental objection to an agency charged solely with inspection is that it will inevitably be slow to take into account changes in the science and technology of the field. One cannot look intelligently for a factory of whose principle of design and operation one has never heard. One cannot effectively inspect if the purpose of the operator is to conceal the discoveries by which he hopes to evade inspection. In a field as new and as subject to technical variation and change as this, the controlling agency must be at least as inventive and at least as well informed as any agency which may attempt to evade control.

Human Factors in Inspection

Even more important than the technical difficulties of realizing an adequate system of inspection, against a background of national rivalry in the field of atomic energy, or through

*Membership of this Technical Committee on Inspection and Control established by the Manhattan District included L. W. Alvarez, R. F. Bacher, L. A. Bliss, S. G. English, A. B. Kinzel, P. Morrison, F. G. Spedding, C. Starr, Col. W. J. Williams, and Manson Benedict, Chairman.

an organization whose major or whose sole directive is suppressive, are the many human factors which in such an arrangement would tend to destroy the confidence and the cooperation essential to its success. The first of these appears when we ask whether it would in fact be possible to recruit the very large and very highly qualified organization of experts and administrators needed for the work. The work itself, which would be largely policing and auditing and attempting to discover evidences of bad faith, would not be attractive to the type of personnel essential for the job. The activity would offer the inspectors a motive pathetically inadequate to their immense and dreary task.

The presence of a large number of "foreigners" necessarily having special privileges and immunities inquiring intimately and generally into industrial and mining operations would be attended by serious social frictions. For adequate inspection the numbers are large. As an example, it has been estimated that for a diffusion plant operated under national auspices, to offer any real hope of guarding against diversion, 300 inspectors would be required. They would have to check not merely accounts and measuring instruments but also individuals personally. Inquiries would need to be made of individuals without regard to rank or general status. Moreover, it would be especially important to check the location and employment of scientists and many technologists, probably including students. Industrial secrets would be at least to some extent open to "prying." The effect of this would

vary with countries. It would probably be obnoxious to Americans as to any others. Its corrosive effect upon the morale and loyalty of the inspecting organization would be serious.

Some of the organizational difficulties involved in intimate inspection "down the line" of one organization by another are known from experiences that are undoubtedly mild compared with what we should anticipate here. The following are illustrative of the political difficulties of practical operation (quite apart from those to be expected in adopting the international system to begin with). Adequate surveillance by inspection as the sole or primary means of control involves a persistent challenge of the good faith of the nations inspected. If this were confined to relations between the chancelleries and general military staffs the difficulty while serious might not be insuperable. But official questioning of the good faith of a nation by concrete action of inspectors among its citizens is another matter and would tend to produce internal as well as external political problems. A somewhat similar problem is involved when a government (or its officials or employees) interferes with the functions of inspectors or molests or threatens them personally, or bribes or coerces them, or is accused of doing any of these things. Such incidents could not be avoided.

Some may question whether nations would possess strong incentives to illicit operations, if they actually agreed to forego the production and use of fissionable materials for purposes of war. It is obvious, however, that suspicion by one nation of

the good faith of another and the fear engendered thereby are themselves strong incentives for the first to embark on secret illicit operations. The raw materials of atomic energy, potentially valuable for new peacetime purposes and of critical importance for war, are already a matter of extreme competition between nations. The forces growing out of this situation and making for acute rivalry between nations seem to us far more powerful than those which cause the present rivalries with respect to such resources as oil. The efforts that individual states are bound to make to increase their industrial capacity and build a reserve for military potentialities will inevitably undermine any system of safeguards which permits these fundamental causes of rivalry to exist. In short any system based on outlawing the purely military development of atomic energy and relying solely on inspection for en-

forcement would at the outset be surrounded by conditions which would destroy the system.

There is much technical information which underlies our belief that inspection can be effective only if it is supplemented by other steps to reduce its scope to manageable proportions, to limit the things that need to be inspected, to simplify their inspection, and to provide a pattern of organization which on the one hand will be of assistance to the controlling agency, and on the other will minimize organizational sources of conflict and the inducements to evasion. Much of this technical information is interwoven with later sections of this report. As the facts on which we base our recommendations for a workable plan of control are discussed, the detailed considerations which led to the conclusion stated in this section will appear more concretely than in the foregoing summary.

Part 2 of this report on the plan of international control will appear in the May issue.

Sound Waves Detect Flaws in Solids

► A SUPersonic reflectoscope using sound waves to locate flaws in solid objects has been developed at the University of Michigan and is being produced commercially, reports Dr. Floyd A. Firestone of the departments of physics and engineering research of the University.

Using a quartz crystal covered with a film of oil to contact the object being tested, the reflectoscope radiates sound waves into the material being tested. The radiated waves reflect back to the instrument and are mag-

nified on an oscilloscope screen. Flaws are detected by variations in the visible oscillations on the screen.

The supersonic reflectoscope sends sound waves into the object being tested for periods as short as a millionth of a second. This produces only a few short-length waves that may be easily read on the screen, and it permits the tester to note quickly flaws in materials being examined.

The supersonic reflectoscope may also be used to determine the level of liquids inside tanks.

Thorium Joins Uranium As Dangerous Element

Thorium and Atomic Fission

► URANIUM stands out as unique among the 92 naturally occurring elements, according to new information released here today in the State Department's Report on the International Control of Atomic Energy. Only uranium can maintain the chain reaction which is the basis for all development of atomic power, whether for peace or war.

Uranium is one of eight or nine heavy, radio-active elements about which there has been speculation ever since the announcement last August of the principles of atomic fission. In particular, the role of uranium's sister element, thorium, largely used to make self-luminous watch dials and light switches, has evoked curiosity.

In the new report it is revealed that thorium cannot of itself maintain a chain reaction, but it can be used with uranium for that purpose. It could, in effect, be used to stretch the uranium supply. Thorium is therefore included with uranium under the restrictive provisions suggested in the State Department's report on atomic energy control.

The fact that thorium and uranium frequently occur together in the same geological formation greatly simplifies this plan for control by international authority of the sources of fissionable material. Moreover the type of geo-

logical formation where these strange minerals occur is unusual and relatively easy to spot.

We have the authority of the scientists who know all the secrets of atomic energy so far discovered that these elements, thorium and uranium, are the only ones over which it is necessary to maintain a watch to insure their use for constructive purposes. Familiar materials, such as iron and lead, may be used freely in construction of atomic power plants, with no danger of producing bombs as a by-product. Nobody is going to get fissionable atoms out of the clay at our feet.

With the world's supply of the dangerous elements, uranium and thorium, and their artificially created analogues, neptunium and plutonium, under international control, the race for fissionable elements as weapons would end in stalemate. At the same time, their use as sources of power and as research tools would offer stimulating opportunity for untrammeled investigation by scientists of all countries. New power sources, secrets of nature's production of food and fuel and new hope in our struggle to understand and control cancer are some of the constructive problems awaiting settlement of the dangerous side of the atomic power question.

Large quantities of soap are used in the wire-making industry to decrease friction as the wire is drawn through dies to reduce it to the desired size.

Navy Surgeon Who Saw A-Bomb Victims Reports Bone Marrow Chiefly Affected

Radiation Sickness Symptoms

JAP VICTIMS of the atomic bomb suffered "true forms of radiation sickness" similar to that seen in the United States in patients who get sick following massive doses of X-rays or radium, Comdr. Joseph J. Timmes, Navy medical officer, reported in a recent issue of the Naval Medical Bulletin.

Comdr. Timmes was one of the first American physicians to see atomic bomb patients in Japan. Aboard the U.S.S. Wichita, he steamed into Nagasaki Ko on Sept. 11, 33 days after the atomic bombing and about 10 days before the arrival of the various scientific commissions.

Fever, a sick feeling, loss of appetite, bleeding gums and bloody diarrhea were the symptoms complained of by the average patient when first brought to the hospital for treatment of A-bomb sickness. Their teeth were loosened and could easily be removed by hand. Gold fillings subsequently examined contained radiant energy. Many lost much of their hair but at the end of a month a few had begun to grow new, downy hair. Whether the baldness will be permanent is at this time "purely speculative," Comdr. Timmes states.

Nitrogen, which constitutes the bulk of the air we breathe, when chemically fixed has a wide range of diverse uses in fertilizers, explosives, plastics, refrigeration, dyes, nylon, petroleum refining, foods, weed killers and fire retardants.

A large percentage of the early victims, it can be assumed, died of the effects of the radiant energy released by the atomic bomb, Comdr. Timmes reports.

The idea that the area would continue to be dangerously radioactive, however, is dispelled by Comdr. Timmes' findings.

Our first concern was the amount of radiant energy possibly remaining in the area and in the victims, he states. X-ray film buried in the bombed area and attached to various objects about the so-called crater (a true crater does not exist) failed to reveal the presence of radioactive elements. Later the other investigators, with the aid of Geiger point counters, reported the area to be safe and found only negligible amounts of radiation.

X-ray films were then attached to the limbs of atomic victims at the hospital and kept in place for 18 hours. All of these films failed to reveal radiation, which may be explained by the fact that although these patients were exposed to forms of radiant energy they did not absorb any in large amounts.

New Radioactive Isotopes Prove Mistaken Identification of 43, 61, 85, 87

Replace Four Elements

► THE PRODUCTION by artificial means of four chemical elements, numbers 43, 61, 85, and 87, now known to be extremely rare or non-existent in nature, was made known by Dr. Glenn T. Seaborg, professor of chemistry at the University of California and codiscoverer of the elements plutonium, 95 and 96 during atomic bomb research, in an address to the physical chemistry section of the Pittsburgh section of the American Chemical Society.

With the manufacture and investigation of the properties of these four elements, all the gaps in the table of chemical elements have been closed. Although all four of these elements have been reported discovered in earlier years by various experimenters, the researches reported by Dr. Seaborg call in question these earlier reports based on less positive methods of analysis.

Actually the experiments with these elements have been performed with unseeable and unweighable amounts by means of the "tracer" technique. The course of the elements in reactions is followed by their radioactivity instead of by chemical means.

Radioactive isotopes of element 43 were produced by the bombardment of molybdenum with deuterons, the nuclei of heavy hydrogen atoms. Experiments by Drs. C. Perrier and Emilio Segre showed that the chemical properties of 43 resembled those of its heavier homolog, rhenium, to

a greater extent than they resembled those of manganese, the lighter element most like it.

Radioactive forms of element 61 were formed in experiments by both Drs. J. D. Kurbatov and Marion L. Pool and Drs. C. S. Wu and Emilio Segre. This element is a rare earth, with a behavior that is to be expected from a rare earth.

Radioactive element 85, whose isotope has an atomic weight of 211, was made by bombarding bismuth with 32,000,000 electron-volt alpha particles. Its general behavior is that of a metal, with little resemblance to the other halogens. Drs. Dale R. Corson, K. R. Mackenzie and Emilio Segre investigated its properties.

A radioactive form of element 87, given the name AcK, has been discovered resulting from the decay of actinium. This isotope discovered by Dr. M. Perey has a mass of 223 and lives but a short time. It decays with negative beta particle emission with a half life of 20 minutes. As was expected, it behaves like a heavy alkali metal.

Earlier reports of the discovery of these elements, now called in question, were made, in the case of 43, named masurium, in 1925, and element 61, named illinium, in 1926, while 85, called alabamine, and 87, called virginium, were announced in 1931. The chemical literature records several earlier claims of finding some of these elements.

Liquid May Replace Water For Warming Radiators

Chemical for Home Heating

by DOROTHY SMITH

► HOME OWNERS who now rely upon water and steam to warm their radiators and baths may find chemical liquids which vaporize at high temperatures the future mediums for conveying heat in their houses.

Engineers convening in New York for the 52nd annual meeting of the American Society of Heating and Ventilating Engineers heard a report on developments in the domestic power field by Orion O. Oaks of the John B. Pierce Foundation. Experiments by the Foundation were begun early in the war in conjunction with the Office of Product Research and Development of the National Housing Agency with a liquid known as tetra-cresyl silicate. This liquid, which may be heated up to 817 degrees Fahrenheit without vaporizing, may well change domestic heating practice.

Two other chemicals are being experimented with for possible domestic application. They are Dowtherm A and Dowtherm E, products of the Dow Chemical Company, now used in industries concerned with molding plastic products, cooking varnishes, processing foods or other high temperature operations. Dowtherm A is a mixture of 73.5% diphenyloxide and 26.5% diphenyl. Dowtherm E has the chemical formula $C_8H_4Cl_2$ (inhibited orthodichlorbenzene). Use of such chemicals, while not new in industry, is new in domestic practice.

Using such "fluid heat" methods, a home could be powered from one source of heat. The independent power plants of the kitchen refrigerator, stove, dishwasher and washing machine might be eliminated. In their place would be a consolidated, single-fluid heating unit which would provide energy for every appliance, including the iron. Special tubing, instead of present electrical wiring, would carry the energy in the form of heat in the liquid around the house.

For use in home units a chemical such as tetra-cresyl silicate or Dowtherm must have high and controllable temperatures with relatively low pressures. Uniformity, non-toxic and non-poisonous characteristics are required. The liquid must have a boiling point many degrees higher than the highest working temperature and be of a permanent chemical structure. It must also be inactive toward materials used in fabrication.

Power and light are planned to be possible with installation of additional equipment. Success in this field would aid many farm communities and areas where power lines do not run. A saving of 48% in favor of liquid heat over anthracite coal is claimed by the Pierce Foundation in their experiments, and such savings would offset any added expenditures in installation of equipment.

Home units are still in the "breadboard" stage, according to Clarence

W. Farrier, Technical Director of the National Housing Agency. One utility core unit consolidates the household heating, plumbing, electrical, bath, kitchen and laundry elements in a space no larger than a closet. Prefabricated, it can be rolled through the house framework during the building period.

This unit, being developed by the Ingersoll Division of the Borg-Warner Corp., could use fluid heat should application seem feasible. A unit known as the Grebe Plan, still in the development stage at the Dow Chemical Midland, Michigan, plant, puts all the kitchen and bath equipment

in a U-shaped unit eight by 12 feet and about room height. The Pierce unit would operate any appliance that utilizes heat, including steam and hot water boilers.

Use of liquid heat would allow various equipment to be integrated into one unit so that piping connections and other parts, including actual appliances, could be factory installed. This would reduce the inefficiency of poor field connections and eliminate numerous separate installations. Continued developments promise great savings and added comfort for home owners of the future.

Penicillin

► PENICILLIN can do a better job of fighting germs in infected wounds when it is protected by a chemical related to carbolic acid, it appears from a report by Dr. Frank L. Meleney, Miss Balbina A. Johnson and Miss Frances Colonna of New York and Capt. Edwin J. Pulaski, of the Army Medical Corps, in a recent issue of the Journal of the American Medical Association.

Surprising as it may be to those who have looked on the mold chemical as almost a cure-all for germ diseases, penicillin is powerless against some germs and its anti-germ power is destroyed by substances these germs produce.

Wounds on the battlefield or in peacetime accidents may become infected with these penicillin destroyers and at the same time with germs that are ordinarily susceptible to penicillin. The problem for the surgeon is to determine which germs are present

Protector

and, if there are penicillin destroyers, to get rid of them so the penicillin can act on the others. If this is not done, and penicillin is used in the wound in ordinary amounts, there is danger that germs ordinarily susceptible to penicillin will develop penicillin resistance because the amount of penicillin in the wound will be reduced by penicillin destroyers below the level needed to destroy susceptible germs.

In a search for a way to overcome this situation, the scientists tested over 200 chemicals and antibiotic agents for their ability to destroy the germs that destroy penicillin. The carbolic acid relative, parachlorophenol, was the most effective of the antiseptics tested. It does not injure the tissues or cause toxic symptoms, can be used with penicillin and can be used as a liquid or as an ointment on gauze dressings.

Lunar Rock Specimens Could Be Jarred Loose by Exploding Rocket

Sampling The Moon

by H. H. NININGER

Director, *The American Meteorite Laboratory, Denver, Colo.*

► ROCKET RIDES to the moon may still be in the far future, yet they seem less fantastically impossible than they did before the war brought revolutionary advances in rocket engineering. Recent successful radar contacts with the moon add the possibility of steering space-navigating rockets with radio beams, and of receiving radio-borne reports of conditions out in the void, from robot sets like those now carried up into the stratosphere by Weather Bureau balloons.

It should be possible to make our first investigations of the stuff the moon is made of without having to wait for passenger-carrying rocket craft capable of making the trip. There is a way of getting geological specimens (or perhaps one should say "lunalogical" specimens) from the moon without actually going there. Hint of how it might be done is furnished by the resourceful geologist who wants some bits of rock from the face of a high cliff, but who has no means of scaling the cliff. He simply fires his rifle at the spot, knocking the specimens loose, and lets gravity bring them to his feet. Similarly, we shall some day be able to launch at the moon a radio-guided rocket with an atomic bomb in its nose. The earth's gravitational pull should bring back some of the pieces the explosion would jar loose.

The moon is only 30 diameters of the earth away from us, and earth and moon are very intimately related gravitationally. Any fragments detached from it and thrown in our direction to a distance of a few thousand miles would be loosed from Mother Moon's apron-strings and would be gathered into the gravitational arms of our planet. On the moon, where gravitation is reduced by five-sixths and atmospheric resistance is nil, very little energy is required to move matter.

Explosives now in common use, to say nothing of atomic bombs, are fully capable of breaking loose chunks of rock and hurling them out at speeds much above the velocity of escape from the moon. Any fragment boosted upward from the lunar surface with a speed greater than about one and one-half miles per second could escape into space. If such a particle were blasted from the lunisphere facing earthward, it would eventually come under the influence of our planet. Once within the earth's gravitational grasp, detached fragments would orient themselves so as to head toward the center of the earth. At least some of these would make a landing.

The journey would not be long in point of time. With an average velocity of three miles a second they

would reach the earth within about thirty hours. This would vary somewhat, depending upon the initial boost administered by the lunar explosion and the directness of the throw relative to our planet.

A wide distribution of observation posts in the equatorial third of the earth's surface should make possible the recording of the arrival of some of these particles. Radar tracking should be able to follow them throughout their long "fall" from moon to earth. They would not flash as meteorites because they would travel at lower velocities, but would probably finally appear as glowing particles in our atmosphere, like the "slow-moving meteors" which observers sometimes report. Indeed, these "slow-moving meteors" may be just the same sort of thing, detached by the landing of meteorites on the moon, a process which must constantly be taking place.

I have previously suggested that the peculiar little glassy blobs known as tektites have had such an origin. Their arrival on the earth has probably followed unusually heavy meteoritic landings on our satellite. The fact that most of the several tektite areas on the earth have been found in the equatorial belt, where land bodies are comparatively scarce, bears out this idea.

Fragments blasted from the moon would necessarily show a preference for that portion of our planet because the course of our satellite as it revolves around us approximates the equatorial plane. Consequently, bodies driving toward the earth's center from the vicinity of the moon, under the guidance of terrestrial gravitation, would encounter its surface in the equatorial zone.

If the world may now enjoy a century of peace we may look forward to the most romantic period of exploration we have ever seen.

Meteorites Menace Rocket Ships

► WHEN A ROCKET ship succeeds in rising into the upper atmosphere, it may have a catastrophic collision with a meteorite, warns Dr. Joseph Kaplan, University of California at Los Angeles, physicist.

Pointing out that the slowest meteorites speed into the earth's atmosphere at a velocity of about 30,000 miles per hour, Dr. Kaplan says that a rocket ship wouldn't have much chance in event of a collision. Faster meteorites, he adds, travel as fast as 180,000 miles per hour.

Upwards of 75,000,000 meteorites plunge into the earth's atmosphere every day, reports the physicist, but almost all of them are vaporized by friction with the air before they can strike the earth. If a rocket ship were sent into the upper atmosphere, he says, it might collide with a meteorite that had not yet vaporized.

Dr. Kaplan says that fortunately meteoric swarms are not very dense, with the most concentrated swarms averaging about one gram (1/30 ounce) of material in 20 cubic miles of space.

Chem Quiz

Who's Afraid of The Big, Bad Atom?

► HERE ARE TEN questions about atomic power, its antecedents and consequences. Which are false, which true? The secret is divulged on page 38.

1. We will soon drive cars powered with atomic energy. True () False ().
2. A spy could easily carry the secret of the atomic bomb around in his head. True () False ().
3. The United States has the monopoly of uranium. True () False ().
4. A chain-reacting pile burns like coal in a furnace. True () False ().
5. A slight difference in tempera-

ture is sufficient to separate the isotopes of uranium. True () False ().

6. The new element plutonium has been found in nature. True () False ().

7. Plutonium disintegrates into uranium 235. True () False ().

8. As soon as the technical difficulties are overcome, we will have small atomic bombs for blasting. True () False ().

9. Radar can protect us against atomic bombs of an enemy. True () False ().

10. The energy in a teacup full of water could drive a steamship across the ocean. True () False ().

Preserving Inactive Naval Vessels

► SCIENTIFIC METHODS will preserve naval ships on an inactive list, yet allow them at any time to make a quick return to duty, the American Society of Civil Engineers was told by Rear Admiral John J. Manning. Preservation procedure now being followed will insure beyond question that inactive vessels will be susceptible of quick recommissioning when necessary.

The modern techniques include dehumidification, protection with film preservatives and plastics and other similar measures. The imperative necessity of maintaining inactive vessels in a much higher degree of preservation than was possible heretofore, he declared, was demonstrated

by our experience in attempting to recommission hastily the World War I vessels which were loaned to Great Britain.

Admiral Manning explained that the Navy now plans to divide its postwar fleet into three basic groups. First would be an active fleet, manned about 70% of war complement; a reserve fleet, manned at 30% of war complement and rotated periodically with the active fleet; and, third, an inactive fleet, to be fully decommissioned and placed in a state of preservation such that it can be reactivated when necessary. In addition, he said, a considerable number of obsolete combat vessels, surplus auxiliaries and landing craft will be disposed of.

Slow Processes of Oxidation Explained by Intermediate Steps

Free Radicals in Nature

► FREE RADICALS—which are chemical entities, not political agitators—were offered as an explanation of certain phenomena in the transformation of organic compounds by Dr. L. Michaelis of the Rockefeller Institute, New York City, in the Sigma Xi Lecture given recently at a number of universities before local chapters of that scientific research society.

Free radicals elude existing means of chemical detection and analysis, Dr. Michaelis stated, because they are only transition groupings of atoms, quickly changing into something else of more stable nature. However, they exercise an important influence on the course of organic reactions, and especially on their rate, since they are held responsible for the much slower pace of oxidation which distinguishes life-processes like respiration from the fast flare of ordinary burning.

An extended interpretation of Dr. Michaelis' lecture by the editors of CHEMISTRY follows:

Life is a process of oxidation, and the energy necessary for carrying on all the activities of living beings comes from the slow burning of organic compounds. How these highly combustible materials can exist surrounded by the oxygen of the air and yet remain so inert that the fires of life are barely perceptible, has long been a puzzle to chemists. Dr. Michaelis finds in the new explanation of chemical combination a clue to the steps by

which these slow oxidations take place, and the reason why the world of living things does not burn up.

Chemists habitually describe the forces that hold elements like carbon, hydrogen and oxygen in combination with each other as valence. This rather vague term, which gives no indication of how the combinations take place, is now being replaced by the idea that the atoms of the elements are in combination because both are holding onto the same electron, or to a pair of electrons shared by the outer orbits of both atomic systems. Dr. Michaelis believes that organic compounds are formed step by step, each step consisting of the "loss" of a single electron, which is "accepted" by the oxidizing agent.

According to the older theory, of the elements making up common organic compounds, carbon has a valence, or combining power, of four, nitrogen three, oxygen two, and hydrogen one. Dr. Michaelis has reason to believe that each of them can act temporarily with a combining power of one, forming what are known as free radicals intermediate between the stable chemical forms with which the reaction starts and ends.

A familiar series of compounds results when methane is oxidized. Methane, known commonly as marsh-gas and to miners as fire-damp, consists of one atom of carbon combined with four atoms of hydrogen. The first

step in its oxidation results in one of the hydrogen atoms being replaced by hydroxyl radical, a combination of an oxygen atom with one of hydrogen. The net result is thus the addition of an atom of oxygen to the compound. The new compound is methyl (wood) alcohol.

Oxidation of methyl alcohol results in the new compound, formaldehyde. Its molecule is composed of one carbon atom, one oxygen atom and two atoms of hydrogen. The other two hydrogen atoms from the methyl alcohol, according to conventional chemistry, combined with oxygen to fly away as water vapor. Dr. Michaelis finds this reaction taking place by two successive steps involving one valence change each. Intermediate between methyl alcohol and formaldehyde he postulates a free radical composed of one carbon, one oxygen and three hydrogen atoms, which is not capable of existence to any analytically measurable extent. Since the overall reaction cannot proceed otherwise than by way of this free radical, there is a barrier established which slows down the rate of oxidation of methyl alcohol when it is exposed to an oxidizing agent. This is why, as a rule, oxidizing reactions in organic chemistry proceed slowly at room temperature, at a measurable and often extremely slow rate.

The slowness of reactions among organic chemicals has heretofore been accounted for by saying that there is an "activation energy" to be overcome. Among all the molecules in the compound, only those few were believed capable of entering new combinations which happened to possess

an energy very much higher than the average energy characteristic of the prevailing temperature. This interpretation can now be remodeled by saying that the rate of oxidation of an organic compound depends on the ease at which the intermediate free radical can be generated. So an essential part of what has been called "activation energy" is the energy necessary to give rise to the free radical, or to climb over that energy hill represented by the making of the free radical.

A free radical may be defined as a molecular species in which one valence is unsaturated, or, in the newer language, one with an odd number of electrons. Since each valence bond is represented by a shared pair of electrons, every valence-saturated molecule must contain an even number of electrons, and a free radical is an "odd molecule." Because of its unsaturated condition, the stability of a free radical will be, in general, less than that of some related, comparable, but valence-saturated molecule. However, this is not always so. Under favorable structural conditions a free radical may be just as stable as a saturated molecule, or sometimes even more stable.

Stability of molecules may be of two kinds. They may be distinguished as thermodynamic stability and kinetic stability. Thermodynamic stability of a free radical comes into the picture when the free radical is intermediate between two compounds which can exist together in the same solution. It is measured by a constant which is characteristic of the kinds and amounts of the compounds present.

Dr. Michaelis illustrates this by the example of the chemical known as hydroquinone and its oxidation product, quinone. Hydroquinone is composed of six carbon and four hydrogen atoms, connected to two hydroxyl groups. Quinone has the same six carbons and four hydrogens, connected to two oxygen atoms. Intermediate between these two compounds in solution is a third, its stem joined to one oxygen and one hydroxyl, which is known as semiquinone. Any solution containing both quinone and hydroquinone will contain some semiquinone, provided the equilibrium is freely established. As a general rule, such an equilibrium is always established rapidly, without any appreciable activation energy.

If, however, the conditions in the solution are such that the two chief compounds cannot exist together in equilibrium, the factor of kinetic stability appears. This is the case when the compounds described above are put into an alkaline solution. The semiquinone in this case will undergo secondary irreversible reactions. Quinone also has the same tendency in an alkaline solution. In such a case we may measure the kinetic stability of the compound as its half-life-time. Many odd molecules have a life-time comparable to that of ordinary, stable organic compounds, so that kinetic instability may often be negligible. Dr. Michaelis in his lecture demonstrated tests by which the presence of such free radicals can be made apparent. Three methods by which they can be detected are potentiometric oxidative titration, the appearance of paramagnetism due to spin of the odd

electron, and color changes in the solution during oxidation or reduction.

A free radical in a solution may combine with another of the same sort to form a double group which is no longer an odd molecule. This doubling is known as dimerization. Semiquinone can form such a dimeric molecule, which is the well known compound quinhydrone. It exists as such in the solid state, but, in solution, dissociates almost, but not quite, completely into its components.

The extent of such dimerization varies considerably among various radicals. The semiquinone radical dimerizes in the dissolved state to a barely noticeable extent. The free radical, triphenylmethyl, on the other hand, dimerizes very appreciably and some of its derivatives dimerize to almost 100%. A free radical does not, however, necessarily have a high tendency to dimerize and so to surrender its unsaturated condition.

Dr. Michaelis discussed the role of free radicals in the oxidation of organic compounds under different conditions of thermodynamic stability. He showed that in the case of hydroquinone, where the thermodynamic factor is fairly great, the semiquinone is formed first. Two molecules of semiquinone interact to form one of hydroquinone and one of quinone, or the semiquinone is oxidized to quinone as a subsequent step of oxidation. The process continues until oxidation to quinone is complete.

When the radical has extremely small thermodynamic stability, as in the case of methyl alcohol being oxidized to formaldehyde, the interme-

diate radical must be formed first. But, because of its low stability, a very powerful oxidizing agent, such as chromic acid, is needed, and still the concentration of the radical will always remain below any analytically measurable amount.

The problem of the living organism is to overcome the activation energy involved in the establishment of the free radical. This is accomplished by catalysts and enzymes. The way a catalyst works is not known in detail, but it is the generally accepted belief that the catalyst combines with the material being oxidized, which the chemist refers to as the substrate. Dr. Michaelis suggests that it would be better to think of the catalyst as combining with both the substrate and the oxidizing agent, so that the electron transfer which completes the reaction can take place within the intermediate molecule. The substrate and the oxidizing agent need not, then, wait for an occasional collision.

They are tied together until the electron transfer, which is thermodynamically possible, occurs spontaneously.

An example from the chemistry of protein compounds was followed in detail by the speaker to illustrate the way understanding of the mechanism in each single case depends upon knowledge of the structure of the specific protein. A full understanding will have to wait until we know more about the spacial structure, not only the composition, of proteins and about those secondary valence forces which enable protein molecules to form molecular aggregates either with each other or with other molecular groups of smaller size.

Dr. Michaelis concluded by describing the particular role of oxygen as an oxidizing agent, combining the properties of being extremely inert from the kinetic point of view, yet, from the thermodynamic point of view, extremely powerful.

Incendiary Jelly Reduces Fire Hazard

► "Goop," the fire-spreading jelly that helped to lay Tokyo and other Japanese cities in ashes, is now playing a paradoxical role in saving American forests from fire. It does this by helping to burn, under watched and controlled conditions, the tops, branches and other debris left after logging operations, which form a bad fire hazard if left to themselves.

"Goop," whose more proper name is Pyrogel, is a greasy jelly containing magnesium powder. It was the most destructive of known incendiary bomb fillers at the end of the war. Another

incendiary mixture, a liquid known as Napalm, also promises to be useful in removal of fire-hazardous forest slash.

The Army has about 50,000,000 pounds of "Goop" left on hand. It has no possible use except to start fires. To destroy it by burning would cost an estimated \$200,000, and dumping it into the ocean would probably produce protests from conservationists. Hence any use that can be made of it in starting slash-removal fires is just so much cash saved to the taxpayers.

Plan Meals With Less Wheat But Cook to Save Vitamins

Wheat Substitutes

by JANE STAFFORD

► HOMEMAKERS wondering how they are going to plan the family's meals on a reduced wheat or flour allowance can get some good tips and probably a few favorite recipes from friends who have been on wheat-free diets because of an allergy to this grain. Oatmeal, rice, rye, cornmeal and potato flour, or potato starch, as it is also known, can be used for cookies, cake, muffins and bread. They will probably prove easier for the housewife to use than the new 80% wheat flour which is expected to take more than average skill to bake into acceptable bread and muffins.

Starchy and sweet vegetables will help supply calories that may be missed if less wheat bread is eaten. These include potatoes, corn, peas, beans, beets and carrots. The peas and beans

also supply some protein and carrots, as most people know, are an excellent source of vitamin A.

Cornstarch, your wheat-allergic friends will remind you, can be used instead of flour for thickening gravies, cream soups and cream sauce or white sauce.

Vitamins in Rice

Whether you eat rice every day, as is customary in some parts of the south, or only once in a while, be sure it is properly cooked to conserve its vitamins. The method advised by the food and nutrition board of the National Research Council is double boiler cooking and no rinsing. Put one cup of rice and one and one-half cups of boiling water in the top of the double boiler and cook until all the water is absorbed. Serve without

Wheat-Saving Muffins

One of the simplest recipes is for potato muffins given in *Dietetics Simplified*, by L. Jean Bogert and Mame T. Porter (Macmillan). Here it is:

1 c. mashed potatoes, warm
1 c. cornmeal
 $\frac{1}{2}$ t. salt
 $\frac{1}{2}$ t. baking powder
1 c. milk
2 T. oil
1 egg
1 T. sugar

Mix dry ingredients. Add milk gradually. Add potato, beaten egg, and oil. Bake in moderate oven 25 minutes.

$\frac{1}{2}$ c. rye flour
 $\frac{1}{2}$ c. rice flour
 $\frac{1}{2}$ level t. baking soda
 $\frac{1}{2}$ level t. cream of tartar
2 t. sugar
 $\frac{1}{2}$ t. salt
 $\frac{1}{2}$ c. milk
1 T. butter

Bake until brown on top (about twenty-five minutes), in the usual moderate oven.

rinsing. You probably need not wash the rice before cooking, either, as most if not all rice sold in retail stores in this country today is clean. You need not use a double boiler if you can cook the rice in the above small amount of water without having it burn at the bottom.

Polished white rice, as you may know, loses vitamins in the milling and polishing process. You get more of these nourishing substances if you eat brown rice. But you will be throwing away large amounts of nourishment from brown or white rice if you cook it in an open kettle with large amounts of water. The National Research Council scientists compared vitamin values in double boiler cooked rice and rice prepared by cooking one-half cup of rice in eight cups of boiling water, transferring to a colander and draining.

Keep Eggs in Water Glass at Low Temperature

► EGGS ARE scarce, and are expected to become scarcer. Persons who own chickens, or have any other means of acquiring surplus eggs, and who intend putting them up in water-glass, a time-honored method of preserving eggs, are advised not to depend on this method alone, but to keep them well refrigerated as well, by Prof. G. O. Hall of Cornell University, who has just concluded a series of experiments in this field.

Eggs of uniform quality were placed in water glass and held for six months. One lot was kept at temperatures of 34 to 36 degrees Fahrenheit, another at 55 to 58 degrees, and a third at ordinary room temperature.

Loss by Rinsing

With this last method, more than 11 times as much thiamin (vitamin B₁) was lost as in the double boiler cooking. The loss of another B vitamin, riboflavin, was six times as great, and the loss of pellagra-preventing niacin was 13 times as great.

"Practically all the vitamins present in rice before cooking can be saved and benefit the consumer when a good method of cooking is employed, using the minimum amount of cooking water and doing no rinsing after cooking," states the report which was written by Dr. M. C. Kik, of the Arkansas State Agricultural Experiment Station and Dr. R. R. Williams, chemical consultant to the Bell Telephone Laboratories, who first synthesized thiamin.

The eggs held at 34 to 36 degrees rivaled fresh eggs in all respects except flavor and odor. Of 189 candled, 178 were of A grade quality or better. Appearance of these eggs on breaking the shells was satisfactory.

Of 239 eggs held from 55 to 58 degrees, 173 had to be classed inedible, according to recognized market classifications, because of stuck yolks.

In eggs held at room temperature (40 to 90 degrees F.), none graded higher than B, and 142 of 187 were graded inedible because of stuck yolks. When broken, these eggs had little or no thick white and the yolks were very flat. It was difficult to break the eggs without mixing yolk and white, Prof. Hall reports.

Glazes on Chintz

► DURABLE GLAZES on chintz, cotton fabric printed with colored designs, can be obtained through the use of relatively new resins developed by the American Cyanamid Company's textile resin division. Chintzes treated with the resin can be washed without loss of glaze, and also without noticeable shrinkage because the new finish greatly limits shrinking.

The resins are melamine formalde-

hyde compounds. Through their use it is now possible to obtain high-gloss glazes that will withstand boiling for a half hour in soapy water, it is claimed, and which are also immune to dry cleaning processes. Another important effect of the treatment with melamine resin is to limit the shrinkage to less than 2% in length or width. Melamine resin treatments are used also for controlling the shrinkage of wool fabrics.

Answers to Chem Quiz on Page 31

► 1. FALSE. Atomic energy power plants have to be shielded so heavily from radio-active fission products that they would be impractical for use in automobiles.

2. False. The so-called "secret" of the atomic bomb lies in tables of mathematical functions, reams of laboratory reports and scientific experience capable of applying this data.

3. False. There are known large deposits of uranium in many parts of the world, and doubtless many still undiscovered.

4. False. Burning is oxidation, combining carbon and oxygen atoms. Fission going on in a chain-reacting pile changes the nucleus of the atom itself.

5. True. The process of thermal diffusion works on this principle.

6. True. Dr. Glenn T. Seaborg, one of the discoverers of plutonium, has found minute amounts of it in an ore of uranium.

7. True. Plutonium is formed from

uranium 238 by beta ray transformation, then it emits an alpha ray and changes into uranium 235.

8. False. The atomic bomb will not explode unless it has a mass larger than the critical mass. Atomic bombs will become larger rather than smaller.

9. False. There is no known protection against the atomic bomb.

10. True (probably, although we can't do it now). It may be possible to use atomic power plants for large ships, where the necessary shielding can be installed. A very small volume of fuel would be required, compared to present day fuel storage needs. What is meant by this frequently repeated statement is the total conversion of the mass of chemical elements into energy. In obtaining energy from present atomic fission only a very small fraction of the mass is so converted. If it ever becomes possible to convert the whole of the atoms of hydrogen and oxygen into energy, this statement would be true.

**New Ideas for Development
In Chemical Industries**

Patents Interesting to Chemists

RECENT PATENTS with a chemical slant are summarized in this article. To obtain a copy of any patent, write to the Commissioner of Patents, Washington 25, D. C., giving the number of the patent and enclosing 10 cents (not in stamps).

► **WEALTH FROM WASTE**, always a fascinating topic in the annals of American industry, finds a new exponent in a New York inventor, Eric W. Eweson, who has just been granted U.S. patent 2,392,811 on a fertilizer made by culturing masses of yeast cells in sulfite liquor, a most objectionable effluent from wood-pulp and paper mills.

To prevent development of too much alcohol, Mr. Eweson bubbles quantities of air through the sulfite liquor while the yeast cells feed on the wood sugars dissolved in it, and on the mineral salts which are introduced. After the yeast has reached maximum growth, the mass is dried and sacked, ready for use.

The inventor claims that his fertilizer contains vitamins and still-living yeast cells, the excess of nutrient salts not used by the yeasts, and the lignin from the wood, the latter serving as a valuable soil conditioner.

Seaweed in Waterproofing

► **ANOTHER NEGLECTED** and largely wasted resource, the giant seaweeds of the Pacific coast, supplies material for an improved bitumen water proof-

ing material, in the formula on which patent 2,393,022 was issued to three San Diego inventors, D. E. Clark, A. B. Steiner and K. F. Gibsen, assignors to the Kelco Company. In it, a salt of alginic acid (the seaweed product) is combined with asphalt, water and a copper-ammonium complex to form a solid, tough, non-tacky compound that is stable over a wide range of temperatures.

Dandelion Rubber

► **ALTHOUGH THE END** of the war has reduced the likelihood of our needing to rely on home-raised rubber-yielding plants, patent 2,393,035 has been granted to two U. S. Department of Agriculture scientists, R. E. Eskew and P. W. Edwards, at the Eastern Regional Research Laboratory in Philadelphia, on a simplified method of extracting rubber from the roots of the Russian dandelions, kok-saghyz and tau-saghyz. The roots are first leached of their carbohydrates with hot water, then mill-crushed to a pulp or slurry, in which the rubber particles agglomerate into relatively large masses. The slurry is then diluted and screened, and the rubber and adhering skins remaining on the screens are scrubbed with water. The resulting slurry is then dispersed in water and the floating rubber is removed while the plant debris sinks.

Rights in the patent are assigned royalty-free to the government.

Foam for Poison Gas

► AN ADAPTATION of a fire-fighting system to decontamination of poison gases is embodied in patent 2,392,936, granted to H. E. Mattin of Brooklyn, N. Y., and L. G. M. Timpson of Plainfield, N. J. Their system calls for spraying contaminated areas with a foam containing the decontaminating chemical. While too late for war purposes, this method appears usable in some of the more hazardous industries.

Weed Killer

► A NEW CLASS of weed-killers chemically related to 2,4-D is covered by patent 2,392,859 taken out by Dr. Lloyd J. Meuli, of the staff of the Dow Chemical Company at Midland, Mich. The herbicidal compounds consist of salts or esters of 2,4-dinitro-6-secondarybutyl-phenol.

Ear Protector

► A WARTIME INVENTION developed under the auspices of the Office of Scientific Research and Development is covered by patent 2,393,005, assigned to OSRD by its inventor, Paul S. Veneklasen of Saugus, Mass. The device, a hollow rubber earplug with a tab to facilitate its insertion and removal, protects the eardrums against the concussion of gunfire and other explosions. It received considerable press notice in the autumn of 1944.

Silicone Lubricants

► USE OF fluid-type silicones as lubricants in making yarns of spun-glass fibers is the basis of patent 2,392,805, granted to L. P. Biefeld of Newark, Ohio, and assigned to the Owens-Corning Fiberglas Corporation.

New Organic Refrigerant

► A NEW FLUID for use in mechanical refrigerants, somewhat on the order of familiar Freon but a little more complex in chemical structure, is covered by patent 2,393,304, granted to three chemists of the Wilmington, Del., area: A. F. Benning, F. B. Downing and Dr. R. J. Plunkett, who have assigned their rights to Kinetic Chemicals, Inc., of the same city.

The new substance is known technically as 1,1,2,2-tetra-fluoro-1-chloroethane, and has the linear formula $\text{CF}_2\text{ClCHF}_2$. Its boiling and freezing points are particularly well suited for refrigeration purposes: it passes from gaseous to liquid state at a temperature of 13.6 degrees above zero Fahrenheit (-10.2° C) and does not solidify until it reaches the low point of 179 degrees below zero Fahrenheit (-117° C).

The refrigerant is made by passing tetra-fluoro-ethylene (C_2F_4) through a tube of quartz or resistant metal containing activated carbon, at a temperature between 125 and 300 degrees Centigrade and under a pressure of from one to 10 atmospheres.

Fuel's Own Oxygen Supply

► A COMPLETELY REVOLUTIONARY idea for fueling internal combustion engines is embodied in U. S. patent 2,393,594, just issued to Dr. Clyde O. Davis, a chemist in the employ of E. I. du Pont de Nemours and Company, to which firm he has assigned rights in his invention.

Dr. Davis' proposal is to use as fuel a solution of ammonium nitrate in liquid anhydrous ammonia. Since ammonium nitrate contains oxygen which can be liberated and imme-

diately recombined with the other elements, such an engine would need no outside source of oxygen, and could operate in the higher stratosphere, in submarines and in other places where air intakes present serious problems. Such an engine would be making use of the principle already successfully applied in guns and powder-propelled rockets; for powder also contains its own internal supply of oxygen, in the form of the nitrate atom-group.

An engine of this type should be non-fouling, for the elemental constituents of the fuel are gaseous at all except the very lowest temperatures. Moreover, since both ammonia and nitric acid can be made synthetically from constituents of air and water, such engines would be completely independent of a dwindling petroleum supply.

Combination Gas-Oil Burner

► A BURNER for furnaces, in which either gas or oil can be used, and the switch from one to the other be made instantaneously, is offered by William A. Clements of Glendale, Calif., for patent 2,393,887. The same pipe and nozzle that blow in the gas inject a blast of high-pressure air when one valve-handle is turned. Opening another valve admits the oil. The air blast atomizes this into spray, which burns in a long, hot flame.

Automatic Packing of Sausages

► A MACHINE for producing skinless sausages in batches, all of them exactly alike, and at the same time automatically packing them into a can or carton, is the invention of 2,393,853, awarded to a Scottish inventor, William Muir Yuill of Edinburgh.

The sausage-meat mixture is forced through a group of sausage-sized holes in a die, over the outside of which the can or carton has been slipped. As the formed cylindrical sausages come out they push the can ahead of them. When the top of the can comes even with the end of the die, a knife slices them across. Then a new can is slipped on and the process is repeated.

Plastic Panels

► PANELS of polished synthetic plastic may be used instead of similar panels made of glued wood veneer in such articles of furniture as desks, beds and cabinets. The panels consist of a phenol-formaldehyde plastic bonded to a backing made of ground cork and vulcanized rubber particles. On this, Paul Van Cleef of Chicago received patent 2,393,843.

Heat Insulator

► A HARD FIREPROOFING surface of plastic-impregnated asbestos or other mineral fibers, cemented onto the face of batts of mineral wool or felt is used for heat-insulating purposes. This is protected by patent 2,393,947, taken out by Manuel R. Ximenez of Plainfield, N. J., assignor to the Johns-Manville Corporation.

Colorful Metal

► VIVIDLY DYED metal surfaces are possible, states Vernon J. King of Baltimore, in his preamble to patent 2,393,640. The metals are pre-treated with an acid bath, developed originally to protect them against corrosion and abrasion. However, such a prepared surface has also been discovered to possess mordant properties, and will take a wide range of dyes, from jet-black to light green.

Keeps Glass Clean

► AN ANTISTATIC composition is intended to prevent the accumulation of dust and lint on glass surfaces, normally attracted and held by electric charges caused by friction. C. S. Myers of Westfield, N. J. states in patent 2,393,863, that he has discovered that a surface layer or film of a solid plastic known as polyethylene glycol over glass will prevent the accumulation of the troublesome static charges.

"Unscrambling" Pentolite

► UNSCRAMBLING the world's toughest eggs is the interesting though touchy procedure which is the basis of a new U. S. patent, No. 2,394,223, just issued here to Joseph A. Wyler of Allentown, Pa., a chemist employed by the Trojan Powder Company. The "scrambled eggs" constitute the terrifically violent explosive mixture known generically as pentolite, used in bazooka projectiles, artillery shells and airplane bombs. It is a mixture of TNT and PETN, which spell out in full as trinitrotoluene and pentaerythritol tetranitrate. For some uses, ammonium nitrate and aluminum power were also added.

The unscrambling process is based on the discovery that while PETN and TNT are both equally soluble in acetone there is a solubility differential between them in water. The first step therefore is to dissolve the explosive mixture in acetone, then add water very slowly, stirring all the while. After sufficient water has been added, the stirring is continued for half an hour or more. During this time the PETN settles out in crystal-

line form, and analysis shows it to be in a high state of purity.

Mr. Wyler has assigned his patent rights to his employing firm.

Centrifuge for Gases

► ANOTHER UNSCRAMBLING JOB, less risky but more difficult, is the assignment of a centrifuge invented by Dr. Norman Carl Beese of Verona, N. J., physicist in the lamp division of the Westinghouse Electric Corporation, and protected by patent No. 2,394,357. The things to be unscrambled are mixtures of gases of differing molecular weights, like nitrogen and oxygen in air, or light and heavy hydrogen.

The centrifuge consists of a wide, flat metal drum, with suitable inlet and outlet connections. The top of the drum is kept constantly warmed by a battery of heat-radiating lamps, while the bottom is kept chilled with jets of water or cold air. This temperature differential is maintained at about 125 degrees Centigrade, and produces a creep of the lighter gas toward the center, while the heavier gas moves toward the periphery.

Wood Sugar Solution

► A PROCESS for "cleaning up" the sugar-containing solution resulting from the treatment of wood with dilute acid is covered by patent 2,394,334, applied for in 1941 by Dr. Heinrich Scholler of Munich, and vested in the Alien Property Custodian. A modification of the Scholler process is now being given a large-scale trial in this country, under the aegis of the U. S. Forest Service.

Dr. Scholler's new development gets rid of impurities in the syrup by thickening it, under vacuum evapora-

tion, to a specific gravity of 1.3 to 1.4. At this density it is kept heated for several hours, then the slightly acid syrup is thinned slightly with water. Impurities settle out as resinous masses, which may be got rid of by centrifuging, filtering or decantation.

Sugar Cane Plastic

► T. R. McELHINNEY of New Orleans, a chemical engineer in the sugar industry, has compounded a new synthetic plastic out of sugar-cane bagasse and phenol, on which he received patent 2,394,000. This promises a new and profitable disposal for a troublesome industrial waste.

Milk with Fizz

► MILK with a "bead" like soda-pop can be produced in a carbonating machine on which Hans Griesbeck, then living in Cologne, Germany, applied for a patent in 1940. The patent, just issued, is No. 2,394,303.

New Adhesives

► INDUSTRIAL ADHESIVES equal to casein can be made from soybean and other vegetable proteins by adding two technical soaps, one made from resin and a fatty acid, the other known as mahogany soap, states Glenn Davidson of Aurora, Ill. Patent 2,394,043 was issued on his formula.

Improved Alloy

► A LEAD ALLOY more resistant to corrosion can be produced by adding very small amounts of manganese (.01% to .10%), according to the formula on which patent 2,394,451 was granted to E. G. Hollman of Joplin, Mo. Other metals added are magnesium and tin.

Push-Button Telephone

► AMERICANS of the present genera-

tion are used to automatic machinery that works when you push a button. Yet the one mechanism probably most often used, the telephone, departs from the push-button principle: you have to stick a finger or pencil tip into holes in a dial and turn it around. Putting the automatic telephone on a push-button basis is undertaken in an invention on which U. S. patent 2,394,926 has just been issued here to Rudolph F. Mallina of Hastings-on-Hudson, N. Y.

On the front of the new instrument, instead of the familiar dial, are ten keys arranged in two banks and numbered from 1 to 0, like the keys of a small adding machine. Within the base, the mechanism is not very much different from that of the dial telephone, for each key is so geared that it turns a master-wheel a different number of spaces. Springs return the mechanism to starting position after each push.

The inventor has assigned his patent rights to the Bell Telephone Laboratories, Inc.

Synthetic Weed-Killers

► A PATENT covering a multitude of things that all perform the one function of weed-killing is No. 2,394,916, obtained by Franklin D. Jones of Llanerch, Pa., chemist associated with the American Chemical Paint Company, to which firm he has assigned his rights.

The weed-killers patented by Mr. Jones all belong to the general family of chemicals commonly described as synthetic hormones or growth-promoting substances. In very small doses they act as stimulants; in higher concentration they are deadly to plants

on which they are sprayed or dusted. As described in the patent, the herbicides belong to "the group consisting of phenyl, naphthyl, tetraryl, and anthracene monocarboxylic aliphatic acids, their salts and esters."

The very sweeping claims made in this patent may provoke some tense legal battles.

Gas Mask Compound

► A MORE EFFECTIVE chemical for the canisters of gas masks is the subject of patent 2,394,887, issued to Prof. Ernst Berl of the Carnegie Institution of Technology at Pittsburgh. Prof. Berl has discovered that if the peroxides of sodium, potassium, magnesium and certain organic radicals are dispersed in a surface-giving carrier such as activated carbon or silica gel, the worst of known war gases contacting the compound are rendered completely harmless. This patent, which was applied for in 1939, apparently is one that had to be withheld during the war for security reasons. Prof. Berl, who has been at his present post since 1933, was chief chemist of the Austro-Hungarian War Ministry during the first World War, and was on the faculty of the Technische Hochschule of Darmstadt, Germany, from then until he came to this country.

Black Stainless Steel

► If you get articles of stainless steel that have a shiny black finish instead of the familiar bluish-white sheen, they will probably have been made by the process on which patent 2,394,899 was granted to I. C. Clingan of Baltimore, assignor to the American Rolling Mill Company. The black finish is obtained by immersing the stainless

steel in a bath of molten potassium dichromate and sodium dichromate for from two to 30 minutes, at a temperature range of 320 to 500 degrees Centigrade.

Low-Cost Niacin

► NIACIN, or nicotinic acid, one of the vitamins used in enriching flour and bread, can be manufactured cheaply by a synthetic process starting with 5, 7-dinitro-8-quinolinol, claims Adolph Zimmerli, Highland Park, N. J., chemist who has received patent 2,394,650. This compound is treated with nitric acid, yielding quinolinic acid. Further nitration, with heating, carries this over into nicotinic acid.

Stronger Ice

► AN EFFORT to overcome the tendency of artificial ice to shatter easily when frozen at too low a temperature is represented in patent 2,394,647, issued to Philip W. West of Baton Rouge, La. Mr. West bubbles carbon dioxide through his water before freezing, then solidifies it at a temperature below 20 degrees Fahrenheit.

Cleaning Steel Scrap

► DR. JOHN WULFF, member of the faculty of the Massachusetts Institute of Technology, has developed a method for salvaging oil-soaked fine tool-steel scrap, on which he has received patent 2,394,578. He mixes the oily sludge with a saponifying agent such as soda ash, tumbles it in a ball mill until the oil is emulsified, floats the scum off, and then divides the ferrous from the non-ferrous particles with a magnetic separator.

Chemical Magic

Egg Rises At Your Command

by JOSEPH H. KRAUS

► COLORED EGGS can be made to rise from the bottom of a column of water-like liquid. Even over-ripe eggs, no longer fit for consumption, can be used for the demonstration.

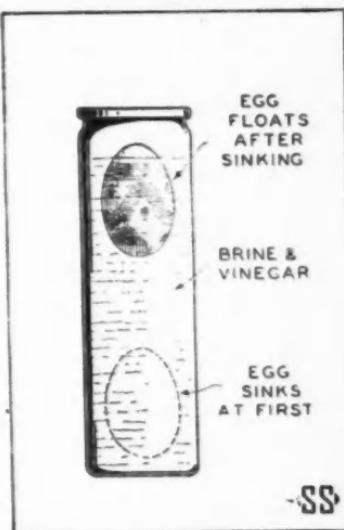
All materials needed are found in the average home: salt, vinegar and water. Preferably use an egg which has been dyed because the effect is better when color or decoration has been added. If possible, the floating wax dyes should be avoided, or they may be removed by washing the egg with soap and water.

Prepare the solution as follows: Pour water into a tall cylinder or bottle. Add salt until the brine so produced is heavy enough to cause the egg to float. Now add water gradually to the brine and stir constantly. This dilutes the salt solution more and more. Finally a point will be reached when the egg remains just barely afloat. Gradually add some white vinegar, stirring all the time. The egg will now sink to the bottom.

Lift out the egg with a spoon and you will be ready to make the egg appear to obey your command.

Before your assembled guests bring forth your cylinder of what will appear to be ordinary water. You can even sip a mouthful.

Now tell your guests that you have an obedient egg which will float to the surface at your command. Pass the egg around for inspection. When your guests have been satisfied that



it is an ordinary egg, drop it into the cylinder of liquid. Immediately it will sink to the bottom.

Watch for the formation of tiny gas bubbles around the egg. Soon you will see that the egg assumes a vertical position and starts to break away from its resting point. At this moment make some mysterious passes over the surface of the cylinder and command the egg to float. It will rise to the surface.

Further to dispel doubts in the mind of any spectator, if you used a boiled egg, remove, peel and eat it. This destroys the evidence and your spectators cannot duplicate the experiment. Give any Doubting Thomas a

wax-dyed egg to try. The trick will fail in his hands.

The egg rises because the vinegar acts on the egg shell, producing bubbles of carbon dioxide gas which remain attached to the surface of the egg and are sufficient to make it float.

The experiment will work with a raw or boiled egg or with an egg which has been lying around for a

long time. The stunt can be worked many times with the same egg merely by removing it from the solution and wiping off the gas bubbles. After a while more vinegar must be added.

The salt does not enter into the composition, but merely increases the specific gravity of the solution by forming a heavier liquid in which the egg will float more easily.



Science Talent Search Winners

As part of the requirements for the Fifth Science Talent Search, just completed, the following essays were written by contestants who were among the group of forty boys and girls brought to Washington by Science Service and the Westinghouse Electric Corp. as finalists in the competition for the Westinghouse Science Scholarships. The trip winners spent five days in the nation's capital attending the Science Talent Institute. They heard outstanding leaders in science tell of the new trends in their fields. They discussed their own problems and hobbies with scientists and with each other. They went sightseeing, to the Department of Agriculture's research center at Beltsville, Md., to the Naval Medical Center and the National Institute of Health at Bethesda, Md., to the Federal Bureau of Investigation laboratories, and the Special Devices Division of the U. S. Navy. The astronomers of the group saw nebulae, stars and planets at the Naval Observatory and the physicists saw a demonstration of the 60-inch cyclotron at the Carnegie Institution's Department of Terrestrial Magnetism.

Up on Capitol Hill, the trip winners had the opportunity to tell the Kilgore Committee of the United States Senate their reasons for favoring S. 1850, the Kilgore bill for establishment of the National Science Foundation and S. 1717, the McMahon bill for control of atomic energy. They got acquainted with the Representatives from their home districts and saw Congress in session and the Supreme Court. They were received at the White House.

On Hobby Night the boys and girls set up exhibits of the samples of their work that they had brought along. Some of these are shown here in the pictures accompanying the essays.

The Furfuran Group of Organic Chemicals

by GEORGE LOWREE GAINES, JR., 15

Hamden High School, Hamden, Conn.

During the past summer, I was employed cleaning equipment, etc., at a research laboratory in New Haven, Connecticut, where work was being done with the furfurans, a group of organic chemicals which in recent years have been obtained in considerable quantities from oat hulls, formerly a farm waste. The particular project under way during the period of my employment there was the manufacture of satisfactory plastic binders from furfuryl alcohol, one of the commonest and cheapest members of the furfuran group. After a few weeks of watching and aiding in this work, both in the laboratory where the polymerization reactions were carried out and in the testing department where the filler samples were made into disks and bars for testing, I began

to be very interested in the furfurans, their uses and preparation, as well as the sources from which they are obtained. I have investigated these things rather extensively, and accordingly, I am now undertaking to tell of my investigations in this essay.

Although the furfuran group includes several other chemicals of some importance, I have been most interested in furfuryl alcohol, with which I had an opportunity to work last summer, and furfural, or furfuryl aldehyde:



which is at the present time the most commercially useful substance of the entire group. The aldehyde, from which the other members of the group are most frequently obtained commercially, is manufactured by the distillation of oat hulls previously digested with mineral acids. Since the oat hulls are very cheap, and the acid required relatively inexpensive as well, the furfural thus obtained is itself far from expensive. In addition the distillate obtained is quite free from impurities, and with one or two further distillations, furfural of high purity is manufactured. From this it can be seen that furfural and other members of the furfuran group are very valuable commercially, due to the great ease with which they can be obtained in a relatively pure state, and since the cost of the raw materials and manufacturing equipment is low.

As noted above, the aldehyde has so far been the most useful of the group from a commercial standpoint. Due to its similarity to formaldehyde, it has found uses in the manufacture of furfural-phenol resins, which are very much like the bakelite plastics in many respects. It has also been used in the manufacture of other types of plastics, both the resinous varieties and as binders for wood pulp, etc., to make low cost structural plastics. In addition, furfural has found extensive use in the synthetic rubber industry. It is exceedingly useful as a solvent, and has found use as a selective solvent in the preparation of butadiene. These properties are also made use of in other industries: furfural has been used as a selective solvent in the purification of anthracene. Due to its great penetrative power, furfural has been used in conjunction with dyes, particularly in the shoe industry, since it is non-toxic, a considerable advantage over aniline and nitrobenzene, also extensively used for this purpose.

However, furfural is not the only useful member of the furfuran group. The



compounds derived from it, such as furfuryl alcohol: are also of much importance. The alcohol is used as a solvent in manners similar to the uses of the aldehyde, including its use as a selective solvent and as a solvent for cellulose products. It possesses an even greater sensitivity to acids than does the aldehyde, and this property, as I have already mentioned, makes furfuryl alcohol a suitable substance for use in preparation of resinous plastics and low cost plastic binders. In this line, the alcohol has been used to treat wood as a protection against rotting, etc. Its penetrating power causes it to soak readily into the wood pores where, upon the addition of some mineral acid, it solidifies and effectively blocks the pores. Other derivatives of furfural include furoic acid and hydrofuranamide, both useful as fungicides. The former



► THE AUTHOR of the essay on acetic acid, Gilbert R. Seely, demonstrates the spectroscope he made; Ilonka Karasz, whose project was on the embryology of the frog, shows some of her preparations; Neal Bert Kindig exhibits gypsum and lime and some of their products; all at the Fifth Science Talent Search hobby show.

is also useful as a bactericide and a solvent, while the latter is a useful antioxidant in the rubber industry. Certain salts of dithiofuroic acid have also been used as accelerators in the rubber industry, and it has been said that these sulfur-furfural compounds may be useful in ore flotation. Some of the other industries which hope to use furfurans are the perfume, felt, and adhesive products manufacturers.

Although this list of present uses for the furfurans may seem impressive, it is in the list of possible future uses for the compounds that the greatest interest lies. It is there that the opportunity for research and discovery shows itself to the true follower of science and learning. Since furfural possesses great penetrating properties, why is it not suited for textile dyes? Could it not be put to use in the manufacture of the textiles themselves? Why not render leather goods waterproof at the same time that they are dyed, by a process similar to the wood-impregnation method described above? Another idea which suggests itself is the possibility of some sort of furfuran-rayon fabric, formed by the extrusion of a cellulose compound similar to that from which

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MISTRY

rayon is made, with which one of the furfuran group is used as a solvent. As in the normal rayon manufacturing process, this solution would be extruded through spinnerets in a mineral acid bath, which would harden the cellulose, and at the same time, form the furfuran into a tough impregnating material, closely united with the cellulose-rayon.

All of the projects mentioned above could probably be worked out with only the two furfurans which I have investigated, the alcohol and the aldehyde. However, there are many more possibilities of the other members of the group which I have not even touched upon. Uses of furacrylic acid in the manufacture of perfume have already been suggested above. If so desired, it would probably be possible to add pleasant odor as well as pleasing color to textiles, etc. by the use of such processes as have already been mentioned.

But to fully carry out a program of experimentation in this field will take many years, the work of many chemists and other trained men, and much money. Some day, however, we may drive over roads built with furfuran binders, in cars built of furfuran plastics, while we wear clothes made of furfuran textiles. These are but a few of the thoughts conjured up by the slight knowledge of the furfurans which we now possess.

► CHEMICALS found in used crankcase oil are explained by James W. Shields.



Mercuriiodides

by JAMES BURTON CUMMING, 17

Andrew Jackson High School, St. Albans, N. Y.

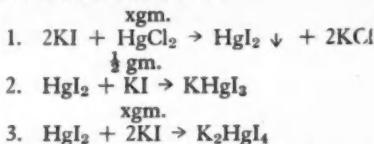
► SEVERAL months ago while preparing cuprous mercuriiodide for a teacher in my school, I became interested in the preparation and properties of this compound and its relatives, the other salts of hydrogen mercuriiodide. The unusual property of cuprous mercuriiodide is its color change on heating and cooling. The change is sharp, being completed in the interval of 2 degrees C. Knowing this, I determined to see if any of the other mercuriiodides had this property and to form some explanation of this phenomenon.

My first experiment was to prepare some more cuprous mercuriiodide for the purpose of testing its transition point. Rather than using hydrogen mercuriiodide as a starting point, I started with potassium iodide and mercuric chloride. The potassium salt of hydrogen mercuriiodide is easily prepared by precipitating mercuric iodide out, washing the precipitate, and dissolving it in excess potassium iodide. I used 6.8 gm. Hg Cl₂ and 8.3 gm. KI to form the mercuric iodide and then dissolved that in another 8.3 gm. of KI in solution. The product was a pale yellow solution. To convert this to the cuprous salt, I added 12 gm. of cupric sulphate. A red-brown precipitate resulted which I judged was unstable since free iodine was found in the solution. To insure complete reduction of the unstable cupric salt, I bubbled sulfur dioxide through the suspension. A bright red precipitate was the result which I filtered, dried and powdered. The transition point of this compound was determined in the apparatus shown in figure 1. The substance to be tested is placed in a glass tube, one end of which has been sealed and drawn out. The thin end is immersed in a water bath and a thermometer in the bath is used to record the temperature of the color change as the bath is heated. The average of several determinations is taken. The main difficulty in this method is that the range is limited to 0° to 100° C. I have tried wax instead of water, but this makes it more difficult to see clearly the portion of the tube immersed. A new method similar to the one used to determine melting points of organic compounds, using concentrated sulphuric acid was also tried, but results were not satisfactory. Cuprous mercuriiodide changes from bright red to a deep purple (almost black) at 71° C. on heating and the reverse on cooling.

Since silver is in the same periodic table group as copper, the next step was to prepare this mercuriiodide. The method was similar to the one used in the cuprous compound, only 10.1 g of silver nitrate were used in place of copper sulphate and the SO₂ treatment was omitted. A bright orange powder was the result. It changes from orange to red at 47° C. on heating.

The nature of these color changes is perplexing. Are they chemical or physical in nature? Before I could attempt any answer to this, I had to know the make up of the mercuriiodide ion. One book represented it as HgI₄²⁻ and another as HgI₃⁻. It was relatively simple to find which one was correct. I prepared a known amount of mercuric iodide and then determined the amount

of potassium iodide needed to dissolve it.



If reaction (2) took place the amount of KI would be one half that needed to precipitate the HgI₂ originally. If (3) took place, the two amounts would be equal. They were equal, hence the mercuriiodide ion can be represented as HgI₄⁻⁻.

If the change in color were chemical, the two forms should react differently. Towards acids and ammonia, both forms of the cuprous mercuriiodide and the silver mercuriiodide react the same, hence the change is probably physical in nature. It might be either a change in the size of the molecule (from perhaps (Cu₂HgI₄)₂ at temperatures below 71° C. to Cu₂HgI₄ above 71°), or a rearrangement of the atoms within the molecule. The latter is the explanation I favor. I assume the HgI₄⁻⁻ ion is in the form of a tetrahedron, with the central mercuric ion surrounded by four ions of iodine. Since this is a negative divalent radical, it would combine with two positive monovalent metallic ions. These could be either on the same side of the tetrahedron or on opposite sides. A shift from one of these positions to the other could easily account for the color change (see figures 2a and 2b). A possible proof of this might be found by using polarized light. If this were passed through a solution of one of the mercuriiodides, that shows a color change, it is probable that a shift in the angle of rotation of the polarized light would correspond to the transition in color and molecular form. For the setup for this experiment see figure 3. At the present time, I am unable to do this, since I have been unsuccessful in finding a suitable solvent.

A deduction which may be drawn from this theory is that a mercuriiodide salt of a divalent metal would not have a color change. This type of salt would be of the form MHgI₄ and there would be only one possible position of the metallic ion relative to the mercuriiodide ion. This holds true in experiment, as far as I have gone, with the exception of cadmium mercuriiodide which shows a very slight color change. Trivalent metals should form compounds of the form M₂(HgI₄)₃ having no color change since the relative positions of the metallic ions between the mercuriiodide ions could not change. Experimentally I have been unable to prepare any trivalent mercuriiodides. The antimony and ferric compounds decompose in solution liberating iodine, and the aluminum and chromium salts would not precipitate out of solution.

In continuing this work I hope to learn more about the reasons certain compounds reflect and transmit particular colors of light. This selective reflection and absorption is undoubtedly due to molecular structure as well as physical form, and increased knowledge in this field might lead to production of better pigments for use in paints and dyes.



► TWO BIOLOGISTS get together at one of the sessions of the Fifth Science Talent Search. Marina Prajmovski, winner of the top girls' Westinghouse scholarship in the First Science Talent Search is talking to Secretary of Commerce Henry A. Wallace, who has just told this year's winners about the genetics of corn and chickens.

Physical Properties of Acetic Acid

by GILBERT RANDALL SEELY, 16

Blaine High School, Blaine, Wash.

► ACETIC acid was chosen for these experiments in physical chemistry for three principal reasons: it can be obtained in all three physical states with comparative ease, it is easily obtained pure, and is comparatively inexpensive.

The principal experiments I have performed and their results are given below.

To find the density of the liquid, a sample was measured in a serological pipette, and weighed to the approximate milligram. The average of these determinations gave the specific gravity as 1.051.

The density of the vapor was obtained by the Victor Meyer method. A dis-

tilling flask was heated in a copper bath until a thermometer in the air in the flask registered 120° C. The temperature of the wall of the flask was later estimated at about 500° A. The side-arm of the flask was connected to a cylinder filled with water, and inverted in a pneumatic trough. The pressure inside the flask was maintained at that of the atmosphere, 765 mm. Then 160 cc. of acid were squirted into the flask, and the volume of air displaced measured in the cylinder. The formula for the density by this method is

$$d = \frac{273mp}{V_o T}, \quad (1.)$$

where m is the mass of acid used, p the pressure in atmospheres, V_o the volume of air collected and corrected, and T the absolute temperature of the vapor. Including corrections, 42.7 cc. of air were displaced, substituting these values in the formula gives the density of the vapor at 500° A. as .00216 g/cm³. If this value is corrected to 391° A., the boiling point, and divided into 60, the molecular weight, the volume of a mole, 22.060 cc., is found for the boiling point.

To find the increase in volume of the liquid when the temperature is increased, a flask filled with the acid was fitted with a stopper and a tube of known bore, so the liquid would be at a certain height in the tube. As the flask was heated, the increase in volume was computed from the rise of the liquid in the tube. The volume was plotted against the temperature. The formula for the volume at a given temperature is

$$V_t = V_o(1 + \alpha t), \quad (2.)$$

where t is the increase in temperature above 24°, and V_o the volume at 24°. Values of α were found for different temperatures and plotted against the temperature.

The density of acetic acid at its boiling point was found, and from this the value of α at the boiling point computed and plotted, with the others, against the temperature. The locus of the points was a straight line, showing α to be a linear function of the temperature. With this correction, the formula for the volume at a given temperature reads

$$V_t = V_o(1 + \alpha t + \beta t^2) \quad (3.)$$

The molar volume of the liquid at the boiling point is an additive and constitutive property. Values can be assigned to the different elements, and from these the molar volume can be computed to a varying degree of accuracy. Computing the molar volume in this way yields 63.8 for acetic acid; by dividing the density at the boiling point, .92, into the molecular weight, 65.3 is obtained for the molar volume.

The expansion of the liquid under diminishing pressure was observed. The apparatus was much like that used for expansion with increasing temperature, but with a vacuum pump employed. Two difficulties made accurate observation impossible: the only vacuum pump available leaked badly, and the acid would begin to boil under low pressures. The rise in the tube was slow at

first, then rapid, and the formula would probably be much like (3.), although due to the difficulties mentioned it was not formulated.

By putting acetic acid in the space above the mercury in a barometer tube, and measuring the height of the mercury column, the vapor pressure of the liquid at different temperatures was observed. The temperature had to be measured from the outside, and the liquid may not have been entirely free from gas, so the results were rather inaccurate.

The viscosity of acetic acid was obtained by comparing the volume that flowed through a capillary tube with the volume of water that flowed in the same time. I obtained a value of 16.1 millipoises for the acid at room temperature.

A quantity of hot glacial acid was immersed in ice water, and the temperature of the liquid plotted against the time. The curve sloped sharply at first, but leveled as the liquid began to freeze. When the liquid was completely frozen, the temperature dropped slowly. The temperature was plotted against the log time. The locus was now a straight sloping line, broken only by the period in which the substance changed state. If $-\Delta Q$ is the heat lost to the surroundings, t the time,

$$-\Delta Q = K \Delta \log t \quad (4.)$$

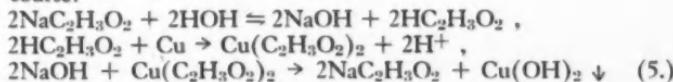
represents the loss of heat, k depending upon the specific heat and temperature of the surroundings. A similar result is obtained when a mixture of water and acid were used, but the mixture does not freeze above 0° C.

Water was added, a millimeter at a time, to a volume of the glacial acid in order to compute the density of the solution. The maximum density, 1.057, was computed when the ratio of water to acid by volume was 3 : 16, or 84% acid.

A mole, 57 cc., of acetic acid was diluted with one mole of water at a time, and the relative conductivity of a fixed volume of the mixture was determined. The conductivity rose, until at 1:8 molal concentration of acid to water a deviation of 6° 45' was recorded. This remained constant on continued dilution. This constant conductivity would continue until the molecules are nearly all dissociated, and on further dilution, less ions are formed than are lost by dilution.

When a 1:10 mixture of acid and water is heated, and the conductivity measured at various temperatures, I found that for a rise of 1° C. a corresponding increase of .0097 in the tangent of the deviation of the needle of the galvanometer occurred.

When a solution of sodium acetate is electrolysed with copper electrodes at the optimum temperature of 30°, a reaction takes place, whereby sodium acetate catalyses the copper into cupric hydroxide. This may be represented by the following equations, all reactions understood to be taking place in ionic form of course:



Using a thermos bottle filler for a calorimeter, I found the specific heat of acetic acid to be .85 cal. per gram, and the heat of fusion to be 59 cal. per gram.

I have only been able to outline briefly the experiments performed with acetic acid; space does not permit a fuller description. These experiments were performed with the intent of observing certain physical laws, and not primarily to establish physical constants for acetic acid.

Study of Pigments

by RUSSELL DEE JOHNSON, Jr., 16

Granite City Community High School, Granite City, Ill.

► SEVERAL THINGS influenced me to begin the study of pigments. I had a fairly well-equipped laboratory in my basement and was accustomed to experimenting. One time, experimenting, I fused manganese dioxide and sodium hydroxide together. A green color resulted. I repeated the experiment several times and always got the green color (sodium manganate). Later, I ran across the term Guignet's green in an Unabridged Dictionary. This was prepared, it said, by fusing potassium dichromate and boric acid. Also I found in an old laboratory workbook that green pigment could be made by precipitating chrome yellow and Prussian blue together. My curiosity was stimulated not only by these chemical aspects but also by some practical applications of paint. First, we had painted our house several times, as the first job was poor and climatic conditions were hard on paint. Second, we had painted our basement floor green three times, and each time the paint had rubbed off the slick-finished floor all too readily. I think I may say that all these things influenced me to study "what makes green paint green."

First, I tried to make Guignet's green. I had no way of weighing out proportions accurately, so the proportions of materials I used were rough in the extreme. After the rather vigorous reaction was through and the crucible was cool, I leached out the excess potassium dichromate, and washed the residue with acid to further purify it. I had difficulty in trying to save the residue. Of necessity the amount of materials used had been small, and most of my green pigment adhered to the filter paper. I attempted the experiment again but kept my results in an impure, dry condition.

Next, I tried the second green, which, I found from other sources, is called Brunswick green. In the first two attempts I used this method: Lead nitrate and ferric chloride were put into solution together. (I was surprised that the lead chloride didn't precipitate out. I don't know why it didn't. The solution was cloudy. This may have been due to hydrolysis of the ferric chloride. I would have heated the solution to clear it, but I was afraid of complete hydrolysis of the ferric chloride.) Separate solutions of potassium ferrocyanide and potassium dichromate were poured into the first solution at the same time. After the resulting suspension was filtered and washed, the same difficulty was encountered as above. I scraped as much as I could from the filter paper with

a pocket knife and transferred the pigments to a sample bottle. The first batch was a dark green, predominantly Prussian blue. The second batch was much lighter, but not so much as to be a yellow-green. The rest of my Brunswick greens I made in a slightly different manner. Potassium ferrocyanide was poured into the lead nitrate-ferric chloride solution; Prussian blue (ferric ferrocyanide) precipitated. Then, while the Prussian blue was kept in suspension by stirring, potassium dichromate was added until the desired shade was reached. I might say here that lead chromate was formed instead of lead dichromate because in water lead dichromate decomposes to the chromate. The pigment was obtained in a dry form by settling, decantation, and evaporation. The lead chromate tended to settle out slightly faster than the Prussian blue. If the soluble impurities were not completely decanted off, needle-shaped crystals (probably $K_2Cr_2O_7$) formed on the surface of the pigment. This was taken care of by further washings, until no more crystals appeared. Once a white precipitate of lead ferrocyanide was formed by inadvertently pouring the potassium ferrocyanide into the lead nitrate before the ferric chloride was put into solution. This seemingly had no effect on the color. The precipitate may have been digested to form the desired precipitate by the other chemicals. The third batch was a rich green; the fourth was much darker. The fifth batch was precipitated on barium sulphate; in other words, it was precipitated in a suspension of barium sulphate, otherwise it was made as the third and fourth batches were made. (I did this to increase the volume of the precipitate.) The tendency of the chrome yellow to settle out first was very marked in this fifth batch. In fact, a blue layer formed on top of the green. Finally, the excess blue was decanted off and a homogeneous green was left. This green was similar in color to the third batch green.

An attempt was also made to make a copper carbonate hydroxide green, along the order of Malachite green. (By this time I had read about pigments in several references.) Copper sulphate solution was treated with a solution of sodium hydroxide and bicarbonate. A light blue-green precipitate resulted, almost a baby blue but a little too green.

I also had read that a chrome oxide green could be formed by reducing potassium dichromate with sulphur. I used too much sulphur and obtained a crumbling, metallic-grey mass instead of the expected green. I would have repeated the experiment but my crucible broke.

I then started to investigate the chrome yellow which made up half of the Brunswick green. My first batch was very successful. The fine precipitate of lead chromate quickly became curdy and settled out completely, leaving the water above clear. After several decantations and washings, the surface of the drying pigment split with wide cracks. When it was dry it was transferred to a sample bottle as the other pigments before it had been. This was a very pure yellow without a trace of orangeness. In texture the pigment was tough. The second batch I diluted with barium sulphate. Due, no doubt, to some impurity in the barium sulphate or in the glassware, this batch was tainted

slightly with an orange color. Although it was nowhere near a real orange, it was red enough to distinguish it plainly from the first bright yellow. Stimulated by the orange tint and by my reading, I determined to produce a deeper red. I knew that basic lead chromate was red pigment. Accordingly, I precipitated the yellow as before and poured sodium hydroxide solution on the pigment, not knowing that the lead chromate was soluble in alkalies. To my consternation, instead of a red color developing, the precipitate dissolved to a cloudy solution. Determined to regain the precipitate, I neutralized the solution slowly with dilute acetic acid. A yellow precipitate developed. It was by chance that I used acetic acid. However, since PbCrO_4 is soluble in other acids but not in acetic, if I had used any other acid, I might not have obtained the precipitate. After standing an hour or so, this precipitate turned red. I finally obtained a brick-red sort of orange color.

Next I turned to zinc chromes. To a solution of zinc chloride I added potassium dichromate as I had to the lead nitrate. No precipitate developed. Checking back, I found that zinc dichromate was soluble, so I used the simple chromate instead of the dichromate. This time I got the zinc chrome. It was not as bright as the lead chrome. A second time I tried and diluted with barium sulphate as I had the fifth batch green. The color was correspondingly lighter. The surface of the drying zinc chrome was of a different character from that of the lead chrome. It had smaller cracks and tiny indentations, like pin-pricks, on the surface.

Later I tried to prepare a basic lead chromate (red) by digesting lead oxide with potassium dichromate. For forty-five minutes I boiled lead sesquioxide with the dichromate solution. A red-orange color was the result, redder than the previous attempt.

Finally, trials were made to utilize these pigments. First some of batch number two, green, was used. I poured the pigment into melted paraffin and stirred the mixture. This was poured into a rolled paper mold and solidified in the ice chamber of the refrigerator. The resulting crayon was too soft for use, so subsequently I used candle-wax, which proved superior to the paraffin. This first experiment was repeated with the candle-wax, producing a creditable crayon which would hardly make any marks, however. A second attempt was more successful. This second crayon made definite dark green marks when rubbed against rough paper. The action was not the same with all parts of the crayon, due to the lumpy nature of the pigment and due to the settling out of the pigment. I also tried to make yellow and red crayons, but the pigment settled out badly and they didn't work. I feel that if I would only make a paste of the pigment and molten wax, I would have better results than I have had making a syrup of them.

In the future I hope to make other pigments such as blue and violet, and to make good crayons from them. I feel that this minor experimentation, while no end in itself, is valuable in that it will develop scientific habits which will be of much use to me in later years.

Synthetic Resins

by WALTER GEORGE GALL, 16

Lincoln High School, Garfield, N. J.

► LIKE many other young boys, my interest in science grew out of a toy chemistry set presented to me at Christmas time several years ago. After I worked through the accompanying book of experiments, I began acquiring a laboratory and library of my own.

I became interested in synthetic resin chemistry early in my organic laboratory experimenting due to the ease and simplicity with which the condensations, polymerizations, etc., are effected and also because the materials and apparatus from which they are prepared were readily available.

In the beginning my experiments were directed toward the preparation of cellulose esters and their plastics. By treating 0.5g. of absorbent cotton with 20cc. of a nitrating mixture (equal volumes of concentrated nitric and sulfuric acids), removing the nitrated cotton at the end of three minutes, washing, and drying, a mixture of the lower nitrates of cellulose was obtained. A colloidal solution of the product in alcohol-ether solvent was allowed to evaporate spontaneously from a watch glass and the resulting celluloid-like film removed. Not only is celluloid made from cellulose nitrate, but so also is it the basis of pyralin plastic, lacquer paints, and liquid court plaster (collodion).

Another cellulose ester was prepared by acetylation of 0.5g. cotton with 20cc. of acetic acid and 8cc. of acetic anhydride using concentrated sulfuric acid catalyst. After precipitation of the reaction mixture in water, washing, and drying, some of the cellulose acetate was dissolved in chloroform and the solvent allowed to evaporate. The manufacture of Cellophane, Plastacele plastic, and Celanese rayon is based on this method.

Turning toward phenolic resinoids, I was largely unsuccessful in preparing a Bakelite type phenol-formaldehyde condensation product. This failure was probably due to the extreme volatility of the formaldehyde solution at the temperatures used, thus preventing it from condensing with the phenol. However, on one mixture a dark crust formed reminiscent of a thin plate of Bakelite. Similar results were obtained using certain homologues of phenol such as the cresols.

Since the poor results obtained above were apparently due to the formaldehyde escaping from the mixture before it had a chance to react, means of generating formaldehyde slowly in the reaction mixture were tried instead of formaldehyde solution. Paraformaldehyde and hexamethylenetetramine are suitable for this purpose and were prepared, the former by evaporation of an aqueous solution of formaldehyde, and the latter by evaporation of an ammoniacal solution of formaldehyde. By heating 10g. of phenol with about 2.5g. of hexamethylenetetramine with stirring until the mixture becomes about as viscous as glycerol and then pouring it onto a folder filter paper and

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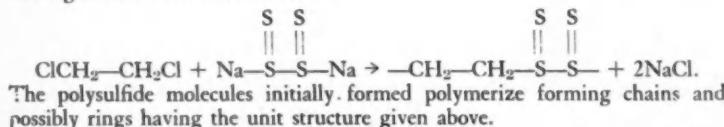
allowing it to remain there until hardened, a beautiful, hard resin ranging in color from light amber to dark red was obtained. The color depends on the length of heating, temperature, and proportion of reactants. This plastic is probably similar to redmanol, a phenol resin produced commercially.

Experimenting with urea derivatives, a methylol-urea molding powder was prepared by warming a mixture of 5g. of urea, 50cc. of water, 5cc. of concentrated hydrochloric acid, and 5cc. of formaldehyde (35-40 per cent solution) on a water bath until precipitation of the condensation product was complete. Various methods of molding were tried but due to limited equipment they were not entirely successful. The plastics made industrially by molding urea-formaldehyde condensates such as these are known under the trade names of Beckamine, Beetle, Plaskon, Rauzite, and Uformite.

In the field of alkyd resins several attempts using different dibasic acids such as phthalic, maleic, succinic, adipic, and sebacic acids heated with glycerol were made. The following general procedure was particularly successful. Five grams of phthalic anhydride (or other dibasic acid or anhydride) were melted and 1-2cc. of glycerol were dropped onto the melted acid with stirring, the mixture then being heated to the boiling point for 5-10 minutes until the point was reached when the increasing viscosity of the mixture made further stirring impracticable. The mixture was then allowed to cool and the resin removed. Resins of this type are used for paints, varnishes, lacquers, and printing inks, and go under trade names such as Glyptal and Amberlac.

Several other resins were prepared also including one type from casein which was produced from milk by precipitation with acetic acid. A jet black resin was prepared in several ways by the action of mineral acids on furfuryl alcohol. The crude furfuryl alcohol used was prepared from furfural by the Cannizzaro reaction which is a dismutation produced by concentrated sodium hydroxide solution (small scale procedure adapted from *Org. Syn., Coll. Vol. 1*, p. 276).

In addition to the classes of plastics already discussed there is a more or less indefinite group of synthetic elastomers. Owing to the difficulty and cost of procuring the basic chemicals and special equipment necessary in the production of artificial rubbers only one type was prepared. This is the ethylene tetrasulfide type of polymer known commercially as Thiokol and produced according to the well known reaction



The first method developed consisted in heating 15g. of crystallized sodium sulfide with 6g. of sulfur in 50cc. of water until complete solution of the sulfur had taken place. This was followed by the addition of 10cc. of ethylene chloride and refluxing at 70° C. for 1 to 1.5 hours.

Another method was also tried. In this modification, 10g. of sodium hydroxide were dissolved in 150cc. of water and heated. As soon as the boiling point was reached, 20g. of sulfur were added slowly with stirring and the mixture was boiled until most of the sulfur had dissolved (10 minutes) and the solution became very dark in color. The dark sodium polysulfide solution was cooled and decanted from the residue of unreacted sulfur. One-half gram of magnesium hydroxide (emulsifying agent for the ethylene chloride) was added to the polysulfide solution which was reheated to 70° whereupon 15cc. of ethylene chloride were slowly added with vigorous stirring, the temperature being kept at about 70° but not over 80° for 15 minutes, and then the mixture was cooled, the polymer washed and dried.

The polymers prepared by the two methods differ somewhat in their physical properties. The one prepared by the first method given above is harder and darker in color than the second product which is a light, greenish-yellow, very pliable solid. However, since the properties of the former product are no doubt due to a greater degree of polymerization, they might be modified by a shorter heating period or in other ways.

Since the best way of learning anything is by doing it, I am engaged in synthesizing and determining the properties of representative members of each of the principal homologous series of aliphatic and aromatic organic compounds at the present time. I have tried many typical reactions including the following: acylation, alkylation, amidation, benzidine and benzilic acid rearrangements, diazotization, Friedel-Crafts reaction, Grignard reaction, Perkin reaction, separation of aromatic position isomers, synthesis of sulfanilamide from acetanilide through *p*-acetylaminobenzenesulfonyl chloride, and synthesis of 1,5-diphenylthiocarbazone from phenylhydrazine and carbon disulfide through the phenylhydrazine salt of β -phenyldithiocarbazic acid. I have also performed several experiments with alicyclic and heterocyclic compounds, notably the synthesis of tetrahydrocarbazole from cyclohexanol through cyclohexanone followed by the Fisher Indole Synthesis on its phenylhydrazone using boron fluoride etherate catalyst (*J. Am. Chem. So.*, 65, 2452 (1943)), extraction of caffeine and theobromine from tea and cocoa respectively, and syntheses involving camphor, furfural, and pyridine.

As for the future, my interests lean specifically toward organic chemical research. It is my firm intention to enter an accredited institution where I will receive the necessary training toward that goal.

* * *

Red phosphorus, used in the rough surface against which Swedish safety matches are scratched, was discovered by Anton von Schrotter nearly 100 years ago.

Sapodilla trees, native to tropical America, yield a highly prized edible fruit, but are more appreciated in the United States perhaps because the bark yields a milky latex known as chicle, the basis of chewing gum.

Improvements in Techniques Made Up for Lack of Craftsmanship

American Wartime Lenses

► THE QUALITY of glass and lens products made in America during the war was superior in certain cases to the German types, and American manufacturers by improvement in techniques turned out camera lenses and shutters equal to, if not better than, any ever produced in Europe, Col. G. W. Goddard of the Air Technical Service Command states in discussing the part played by photography in the war effort.

Col. Goddard gives high praise to American glass and lens makers who, he says, "made up the lack of traditional craftsmanship by improvements in technique" which produced the superior products, and produced them in sufficient quantities to meet the wartime needs.

An industry that turned out not more than 50 to 100 aerial lenses of any one type in a year and then geared itself to produce as many as 1,200 first class aerial lenses a month of a single type to meet wartime needs, deserves to be complimented, he declares.

Col. Goddard inspected German research development and production facilities after V-E Day. This inspection, he says, revealed that technical progress of German color photography had not kept pace with Eastman Kodak Kodachrome and Kodacolor processes in regard to quality and simplicity of production.

It also revealed, he adds, that all German color film exposed during

the African campaign had to be sent to a central laboratory near Berlin for developing, while American Kodacolor and camouflage detection could be processed in tent or trailer laboratories in the field in all climates anywhere on the globe.

Surprisingly, German aerial equipment, generally speaking, was not up to the standard as presupposed. The German types of night aerial flash and camera equipment, bomb strike cameras, aeronautical charting cameras, shutterless strip cameras, combat recording cameras, portable laboratories and related equipment were inferior to the American types which were rapidly produced in large quantities and made available to American, British, French and Russian Air Forces through lend-lease.

As an accomplishment of special note, Col. Goddard refers to a new film sensitive to both ordinary light and infra-red rays. It was noted, he says, that German camouflage paint reflected all but infra-red rays, while the chlorophyll in natural foliage reflects infra-red perfectly.

Army aerial photographic laboratory here told Kodak that the Army needed a film which would be sensitive to both infra-red and ordinary light. Kodak came through with a multi-layered film that separated the unnatural from the natural foliage and exposed some of Germany's most concealed hide-outs.

Cuba Supplied Chromium

► THE IMPORTANT PART played by Cuba in supplying America with chrome ore during the war, and wartime explorations in Cuba by American scientists to discover new chromium deposits, were reviewed by Philip W. Guild of the U. S. Geological Survey at a meeting of the American Institute of Mining and Metallurgical Engineers, in joint session with the Pan-American Institute of Mining Engineering and Geology.

Cuba's contribution of chrome ore, he stated, was approximately 40% of the total imported during the war years, a vast increase over the 5% to 20% supplied by this island neighbor during the period before the war. Cuba's increase made up in part for the loss of chrome from the Philippines, British India, Greece and Turkey. Chrome is essential in making the hard steels for ships, tanks, cannon and other fighting equipment.

Domestic production of chromium ore was greatly increased during the war, but the total mined was far short of the requirements. The United States has always relied principally on imports. In 1940, for instance, America produced 2,662 tons of ore, and imported nearly 658,000 tons.

In 1940 the effects of the war began to be felt, and increased mining activities in Cuba resulted in a sharp upswing in production, Mr. Guild said. During the same year representatives of the U. S. Geological Survey went to Cuba to study the situation. They made studies to determine the overall distribution of ore and possible controlling factors in its deposition, and made maps of deposits.

The existence of chromite deposits in Cuba has been known for many years, but no use of these ores was made until the time of the first World War. Development following the war was slow because Philippine ore could be delivered to Baltimore at a price that could not be met by Cuban producers except from a few very favorably situated mines.

The future of Cuban chromite in America depends upon future Philippine competition, and also upon prospecting and development work in the more remote areas of the island, Mr. Guild added.



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